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CITY OF BOSTON.

TWENTY-SECOND ANNUAL REPORT

OF THE

CITY ENGINEER,

FOR THE YEAR 1888.

Office of the City Engineer, City Hall,
Boston, Jan. 14, 1889.

To the Honorable City Council: —

In compliance with the seventh section of the ordinance relating to the Engineer's Department, the following report of the expenses and operations of the department for the year 1888 is respectfully submitted: —

The duties of the City Engineer may be classified under the following heads: —

A. — Those pertaining to the City Engineer's Department proper, which consist in examination and supervision of structural repairs of bridges; in designing and superintending the construction of new bridges, retaining-walls, city wharves, etc., and in miscellaneous engineering work called for by the City Council. (City Engineer's Department.)

B. — Superintendence of the Sudbury-river, Cochituate, and Mystic Water-Works, including charge of new constructions for these works. (Water-Works.)

C. — Charge of the construction of a system of intercepting and outlet sewers. (Improved Sewerage, or Main Drainage.)

D. — Charge of the engineering work in connection with the Back-Bay and other proposed parks. (Parks.)

The expenses incurred under the head C are paid wholly from a special appropriation.

A. — City Engineer's Department.

The following is a statement of engineering expenses from January 1, 1888, to January 1, 1889: —

Amount expended from department appropriation for 1887–88	$9,472 47
Amount expended from department appropriation for 1888–89	23,686 57
Total	$33,159 04

Condition of department appropriation: —

Amount of appropriation for financial year 1888–89	$34,000 00
Amount expended to January 1, 1889 . .	23,686 57
Unexpended balance, January 1, 1889 .	$10,313 43

Classification of Expenses.

Salaries of City Engineer, assistants, draughtsmen, transitmen, levellers, rodmen, etc. .	$30,403 75
Engineering instruments and repairs of same .	110 54
Drawing-paper, and all materials for making plans	334 04
Stationery, printing-stock, note-books, postage, etc.	309 86
Reference library, binding books, and photographs of work	441 89
Printing	87 74
Travelling expenses (including horse-keeping, repairs on vehicle, etc.)	511 73
Telephone service	125 75
Furniture cases for plans and books, etc. .	185 50
Blue-process printing	130 33
Incidental expenses, and all other small supplies	180 41
New buggy and harness	337 50
Total	$33,159 04

The number of persons employed and paid from the department appropriation was, on the 1st of January, 1888 (including the City Engineer), 20. The present number is 21. The operations of the department for the year, together with such general information relating to the various works and structures, finished and in progress, as is thought to be of interest, are given in the following statements: —

BRIDGES.

In accordance with Section 5, Chapter 18, of the Revised Ordinances, the estimates of cost of repairs submitted by the Superintendent of Bridges has been revised and reported upon, and structural repairs required have been ordered and supervised.

As required by Section 4 of the above, examinations have been made of all highway bridges within the city limits, and the usual routine work of superintending the repairs made by the Bridge Department upon those in its charge has been done.

In addition to the regular annual report, a special report on the condition of the city bridges was made in obedience to an order of the City Council. (See City Doc. No. 117, 1888.)

LIST OF BRIDGES INSPECTED.

Three bridges have been added to the list this year, — Boylston street, over Boston & Albany Railroad; Agassiz-road Bridge, in Back Bay Fens; and Neptune-road Bridge, in East Boston.

In the list, those marked with an asterisk are over navigable water and are each provided with a draw.

I. — BRIDGES WHOLLY SUPPORTED BY BOSTON.

Agassiz road, in Back Bay Fens.
Ashland street, Ward 23, over Boston & Providence Railroad.
Athens street, over New York & New England Railroad.
Beacon Entrance, Back Bay Fens, over Boston & Albany Railroad.
Beacon street, over outlet to Back Bay Fens.
Beacon street, over Boston & Albany Railroad.
Berkeley street, over Boston & Albany Railroad.
Berkeley street, over Boston & Providence Railroad.
Blakemore street, over Boston & Providence Railroad, Ward 23.
Boylston street, in Back Bay Fens.
Boylston street, over Boston & Albany Railroad.
*Broadway, over Fort Point Channel.
Broadway, over Boston & Albany Railroad.
Brookline avenue, over Boston & Albany Railroad.

*Charles river, from Boston to Charlestown.
*Chelsea (south), over South Channel, Mystic river.
*Chelsea street, from East Boston to Chelsea.
Columbus avenue, over Boston & Albany Railroad.
*Commercial point, or Tenean, Ward 24.
Commonwealth avenue, in Back Bay Fens.
*Congress street, over Fort Point Channel.
Dartmouth street, over Boston & Albany and Boston & Providence Railroads.
*Dover street, over Fort Point Channel.
*Federal street, over Fort Point Channel.
Ferdinand street, over Boston & Albany Railroad.
Franklin-street foot-bridge, over Boston & Albany Railroad.
Huntington avenue, over Boston & Albany Railroad.
Linden Park street, over Stony brook.
*Malden, from Charlestown to Everett.
*Meridian street, from East Boston to Chelsea.
*Mt. Washington avenue, over Fort Point Channel.
Neptune road, over Boston, Revere Beach, & Lynn Railroad.
Newton street, over Boston & Providence Railroad.
Public Garden foot-bridge.
Shawmut avenue, over Boston & Albany Railroad.
Swett street, east of New York & New England Railroad.
Swett street, west of New York & New England Railroad.
*Warren, from Boston to Charlestown.
West Chester park, over Boston & Albany Railroad.
West Chester park, over Boston & Providence Railroad.
West Rutland square foot-bridge, over Boston & Providence Railroad.
Winthrop, from Breed's Island to Winthrop.

II. — BRIDGES OF WHICH BOSTON SUPPORTS THE PART WITHIN ITS LIMITS.

*Cambridge street, from Brighton to Cambridge.
Central avenue, from Ward 24 to Milton.
*Chelsea (north), from Charlestown to Chelsea.
*Essex street, from Ward 25 (Brookline) to Cambridge.
*Granite, from Dorchester, Ward 24, to Milton.
Longwood avenue, from Ward 22 to Brookline.
Mattapan, from Ward 24 to Milton.
Milton, from Ward 24 to Milton.
*Neponset, from Ward 24 to Quincy.
*North Beacon street, from Brighton to Watertown.
*North Harvard street, from Brighton to Cambridge.

Spring street, from West Roxbury to Dedham.
*Western avenue, from Brighton to Cambridge.
*Western avenue, from Brighton to Watertown.

III. — BRIDGES OF WHICH BOSTON PAYS A PART OF THE COST OF MAINTENANCE.

Albany street, over Boston & Albany Railroad.
*Canal, from Boston to Cambridge.
Dorchester street, over Old Colony Railroad.
*Prison Point, from Charlestown to Cambridge.
*West Boston, from Boston to Cambridge.

IV. — BRIDGES SUPPORTED BY RAILROAD CORPORATIONS.

1st. — Boston & Albany Railroad.

Commonwealth avenue, Brighton.
Harrison avenue.
Market street, Brighton.
Tremont street.
Washington street.

2d. — Boston & Maine Railroad, Western Division.

Mystic avenue.
Main street.

3d. — Boston & Maine Railroad, Eastern Division.

Mystic avenue.
Main street.

4th. — Boston, Revere Beach, & Lynn Railroad.

Everett street.

5th. — New York & New England Railroad.

Broadway.
Dorchester avenue.
Fifth street.
Forest Hills avenue, Ward 24.
Fourth street.
Harvard street, Ward 24.
Norfolk " " "
Norfolk " " "
Second street.
Silver street.
Sixth street.
Third street.
Washington street, Ward 24.

6th. — Old Colony Railroad.

Adams street.
Ashmont street and Dorchester avenue.
Cedar Grove Cemetery.
Commercial street.
Savin Hill avenue.

7th. — Old Colony Railroad, Providence Division.

Beech street, Ward 23.
Bellevue street, Ward 23.
Canterbury street, Ward 23.
Centre street, or Hog Bridge, Ward 23.
Centre and Mt. Vernon streets, Ward 23.
Dudley avenue, Ward 23.
Park street, Ward 23.

RECAPITULATION.

I.	Number wholly supported by Boston	42
II.	Number of which Boston supports the part within its limits	14
III.	Number of which Boston pays a part of the cost of maintenance	5
IV.	Number supported by railroad corporations: —	
1.	Boston & Albany	5
2.	Boston & Maine, Western Division	2
3.	" " Eastern Division	2
4.	Boston, Revere Beach, & Lynn	1
5.	New York & New England	13
6.	Old Colony	5
7.	" " Providence Division	7
	Total number	96

I. — BRIDGES WHOLLY SUPPORTED BY BOSTON.

AGASSIZ-ROAD BRIDGE (IN BACK BAY FENS).

This is a new bridge, built in 1887, of brick and stone masonry, and was opened to the public on Oct. 2, 1888. It is maintained by the Park Department, and is in good condition.

ASHLAND-STREET BRIDGE (OVER BOSTON & PROVIDENCE RAILROAD, WARD 23).

The present structure is of iron, and was built in 1875.

No work has been done on this bridge, and it is in good condition.

ATHENS-STREET BRIDGE (OVER NEW YORK & NEW ENGLAND RAILROAD).

This is an iron bridge, and was built in 1874.

It needs painting; otherwise it is in good condition.

BEACON-ENTRANCE BRIDGE (IN BACK BAY FENS, OVER BOSTON & ALBANY RAILROAD).

This is an iron bridge, and was built in 1881–82.

It is maintained by the Park Department, and is in good condition.

BEACON-STREET BRIDGE (OVER OUTLET OF BACK BAY).

This is an iron bridge, and was built in 1880–81.

It has been sheathed, and is in good condition.

BEACON-STREET BRIDGE (OVER BOSTON & ALBANY RAILROAD).

This is an iron bridge; it was built in 1881–82, and was widened in 1887–88.

The work of widening this bridge was finished during the year, and it is in good condition, except that it needs painting.

BERKELEY-STREET BRIDGE (OVER BOSTON & ALBANY RAILROAD).

This is an iron bridge. It was built by the Boston Water Power Company, and was accepted by the city in 1869.

No changes have been made on this bridge, and it remains in the condition heretofore reported. It is not strong enough for the position it occupies. It is on a wide street, much used for public processions. Both bridge and abutments should be rebuilt. The sidewalks and some of the floor timbers must be renewed.

BERKELEY-STREET BRIDGE (OVER BOSTON & PROVIDENCE RAILROAD).

This is an iron bridge. It was built by the Boston Water Power Company, and was accepted by the city in 1869.

The concrete sidewalks have been put in order during the year, and the bridge has been painted. It is in fair condition.

BLAKEMORE-STREET BRIDGE (OVER BOSTON & PROVIDENCE RAILROAD).

This is an iron bridge. It was built in 1881–82.

The bridge needs painting; otherwise it is in good condition.

BOYLSTON-STREET BRIDGE (IN BACK BAY FENS).

This is a stone masonry bridge, and it was built in 1881–83.

It is maintained by the Park Department, and is in good condition.

BOYLSTON-STREET BRIDGE (OVER BOSTON & ALBANY RAILROAD).

This is an iron bridge, and it was built in 1886–88.

This is a new bridge just opened to travel. For description of iron-work see page 19. The abutments were described and illustrated in last year's report.

* BROADWAY BRIDGE (OVER FORT-POINT CHANNEL).

This is an iron bridge. It was built in 1869–71, and the draw and its foundation were rebuilt in 1874–75.

The wood-work of the bridge below low-water mark has been examined by a diver; the front of the draw pier was found to be so weakened from the attacks of the limnoria that it will be necessary to rebuild it in a few years. The remaining wood-work under water is in better condition, and will last some years longer.

The spans over Foundry and Lehigh streets and the two 100-feet spans are of light construction, and will soon have to be replaced by stronger structures. The steep grades at each end of the bridge save it from much heavy teaming.

Three varieties of asphaltic roadway pavement have been laid on this bridge at the expense of the new Harvard Bridge, for experimental purposes; an area of about 12 × 50 feet of each kind having been laid. Repairs are necessary to the sidewalks, and one of the 100-feet spans requires a new under-floor.

BROADWAY BRIDGE (OVER BOSTON & ALBANY RAILROAD).

This bridge is of iron, was built in 1880–81, and is in good condition.

BROOKLINE-AVENUE BRIDGE (OVER BOSTON & ALBANY RAILROAD).

This bridge is of iron, and was built in 1884. It has been painted, and is in good condition.

*CHARLES-RIVER BRIDGE (FROM BOSTON TO CHARLESTOWN.)

This is a wooden pile bridge with an iron draw. The original bridge was built in 1785–86, the present structure was built in 1854–55, and the draw was built in 1870. It is an old bridge, and is only in passable condition.

The draw foundation has been repaired, and is now in fair condition.

The piling has been carefully examined below low-water mark by a diver, and a few piles were found to have been slightly damaged by the limnoria, — not more than six or eight being discovered out of about 700 examined, and in no case was serious weakness found. The piles above low tide are worn, and many of them are in poor condition. The roadway floor and the paving are also in poor condition. It will be necessary to rebuild this bridge at an early day.

Repairs are necessary to the under-floor. New trucks are required, the draw should be repaired, and the roadway needs repaving.

*CHELSEA BRIDGE, SOUTH (OVER SOUTH CHANNEL, MYSTIC RIVER).

This a pile bridge with an iron draw. The original bridge was built in 1802–3, and the present structure in 1876–77. Only the usual repairs have been made, and the bridge is in fair condition.

Repairs are required on the timber-work and on the track.

*CHELSEA-STREET BRIDGE (FROM EAST BOSTON TO CHELSEA).

This wooden pile bridge was originally built in 1834, and was rebuilt in 1848; the present structure was built in 1873, and the draw was built in 1868.

The draw and draw foundations are in bad condition, being old and decayed, and the piling of the foundation has been seriously injured by the limnoria. The draw should be rebuilt and widened during the coming year, it now being only 22 feet in width.

The fixed part of the bridge is in fair condition. It will be necessary to rebuild the bridge above the piles to a higher grade when a new draw is built.

It is necessary to repair the draw this year.

COLUMBUS-AVENUE BRIDGE (OVER BOSTON & ALBANY RAILROAD).

This is an iron bridge, was originally built in 1865, and the present structure was built in 1876–77.

The wire guys attached to the main trusses, mentioned in last year's report, have not been removed. The bridge has been painted, and is in fair condition.

*COMMERCIAL-POINT OR TENEAN BRIDGE (WARD 24).

This is a wooden pile bridge with a wooden leaf draw. It was originally built in 1833, and the present structure was built in 1875.

Both the upper and under roadway planking has been renewed and a few stringers added. The bridge is in fair condition.

COMMONWEALTH-AVENUE BRIDGE (IN BACK BAY FENS).

This is an iron bridge, and it was built in 1881–82. It is in good condition.

*CONGRESS-STREET BRIDGE (OVER FORT-POINT CHANNEL).

This is a wooden pile bridge with an iron turn-table draw on a stone masonry foundation. It was built in 1874–75.

The piling was examined by a diver and found to be only slightly damaged by worms. Some of the piles have been renewed on account of decay above the water-line, and some others should be renewed.

The floor of the bridge is in poor condition; it has been patched, and about one-half of it must be renewed.

The vacant spaces under the bridge adjoining the old Russia wharf, mentioned in last year's report, have been filled and the paving relaid.

DARTMOUTH-STREET BRIDGE (OVER BOSTON & ALBANY AND BOSTON & PROVIDENCE RAILROADS).

This is an iron bridge; it was originally built in 1869, and the present structure was built in 1878–79.

The under-floor is poor; otherwise the bridge is in good condition.

*DOVER-STREET BRIDGE (OVER FORT-POINT CHANNEL).

This is a wooden pile bridge, with an iron draw; it was originally built in 1805, was rebuilt in 1858–59, and the present structure was built in 1876. The work of widening the water-way to the legal limit of 36 feet is nearly completed. The under-floor of the bridge requires patching; otherwise the bridge, as a whole, is in fair condition.

*FEDERAL-STREET BRIDGE (OVER FORT-POINT CHANNEL).

This bridge was built in 1827–28, was rebuilt in 1857–58, and the present structure was built in 1872–73.

It is a wooden pile bridge with a double wooden draw. It is in bad condition, and should be rebuilt at once. (See special report to Mayor, Oct. 8, 1888. Appendix B, Doc. 117, 1888.)

Repairs must be made to the trucks, draw, under-floor, fences, and paving, at an estimated cost of $5,000, if the bridge is not rebuilt.

FERDINAND-STREET BRIDGE (OVER BOSTON & ALBANY RAILROAD).

This is an iron bridge. It was built in 1864–65, and was strengthened in 1877.

The recommendation made last year is renewed; that is, that the part supported on posts be filled solid, and that the bridge be rebuilt.

FRANKLIN-STREET FOOT-BRIDGE (OVER BOSTON & ALBANY RAILROAD).

This is an iron bridge. It was built in 1883, and is in good condition.

HUNTINGTON-AVENUE BRIDGE (OVER BOSTON & ALBANY RAILROAD).

This is an iron bridge. It was built in 1872, and the abutments were rebuilt in 1876–77.

It is in good condition.

LINDEN PARK-STREET BRIDGE (OVER STONY BROOK).

This is a wooden truss bridge. It was built in 1886, and is in fair condition.

*MALDEN BRIDGE (FROM CHARLESTOWN TO EVERETT).

The original bridge was built in 1787. The present structure was built in 1875, and the draw was built in 1872.

It is a pile bridge with a wooden turn-table draw on a pile foundation. The fixed part of the bridge is in good condition; the draw is old, narrow, in poor condition, and can be kept in a safe condition but a short time longer.

The piling has been examined by a diver and found to be in good condition.

*MERIDIAN-STREET BRIDGE (FROM EAST BOSTON TO CHELSEA).

This is a wooden pile bridge with a wooden turn-table draw on a pile foundation. The original structure was built in 1856. It was rebuilt soon afterwards; it was widened and rebuilt as at present in 1884, excepting the draw, which was built in 1875–76.

The draw needs repairs, which have been ordered and artly made; it shows signs of age, but will serve for some years to come. The piles have been examined by a diver and found in good condition. The fixed part of the bridge is in good condition.

*MT. WASHINGTON-AVENUE BRIDGE (OVER FORT-POINT CHANNEL).

This is a wooden pile bridge with an iron draw. It was built in 1854, and was rebuilt in 1870–71.

The usual necessary repairs have been made, and the bridge is in fair condition.

NEPTUNE-ROAD BRIDGE (OVER REVERE BEACH & LYNN RAILROAD IN EAST BOSTON).

This is an iron bridge, and it was built in 1887–88.

It is maintained by the Park Department, and is in good condition.

NEWTON-STREET BRIDGE (OVER BOSTON & PROVIDENCE RAILROAD).

This is an iron bridge, and was built in 1872.

It has been painted, and is in good condition.

PUBLIC GARDEN FOOT-BRIDGE.

This is an iron bridge. It was built in 1867, and was thoroughly repaired in 1887.

It is in good condition.

SHAWMUT-AVENUE BRIDGE (OVER BOSTON & ALBANY RAILROAD).

This is an iron bridge, and it was built in 1871.

It needs painting, and the iron-work should be stripped for this purpose and also to allow of a careful examination. Only the usual repairs have been made.

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SWETT-STREET BRIDGES (OVER SOUTH BAY SLUICES).

These are wooden bridges, and were built in 1875.

The easterly bridge has been replanked, both upper and under courses, and the sidewalks and fences renewed. The pile bulkheads have not been repaired, and are in bad condition. The westerly bridge is in poor condition.

*WARREN BRIDGE (FROM BOSTON TO CHARLESTOWN).

This is a wooden pile bridge with an iron draw; it was originally built in 1828, and the present structure was built in 1883–84. The usual minor repairs have been made, and the bridge has been painted. It is in fair condition. A count of teams and foot passengers, on Dec. 20, 1888, showed the following results: —

Hourly record of pedestrians, teams, and horse cars, passing over each draw from 6 A.M. to 7 P.M., Thursday, Dec. 20, 1888. Omnibuses average 23 per hour. Weather, cold and windy; cloudy and snow squalls in A.M.; pleasant in P.M.; ground free from snow.

Time.	Pedestrians.	Teams.				Horse Cars.	Miscellaneous.
		One-horse.	Two-horse.	Three-horse.	Four-horse.		
6 to 7 A.M. . . .	909	84	44	0	1	53	
7 to 8 " . . .	1,356	348	129	0	0	87	
8 to 9 " . . .	829	333	106	1	4	95	
9 to 10 " . . .	561	343	145	4	4	90	1 six-horse team.
10 to 11 " . . .	578	381	144	3	4	93	1 " "
11 to 12 " . . .	529	347	129	4	4	90	
12 to 1 P.M. . . .	735	326	117	2	1	94	
1 to 2 " . . .	751	274	131	5	7	99	
2 to 3 " . . .	606	388	102	6	7	97	
3 to 4 " . . .	712	394	128	1	5	106	
4 to 5 " . . .	922	419	116	6	3	103	32 horses, without vehicles; 1 bicycle.
5 to 6 " . . .	1,285	501	153	3	6	114	
6 to 7 " . . .	1,762	139	46	0	0	103	
Total	11,535	4,277	1,490	35	46	1,224	

Number of foot passengers on westerly sidewalk, 8,582.
Number of foot passengers on easterly sidewalk, 2,953.

WEST CHESTER PARK BRIDGE (OVER BOSTON & ALBANY RAILROAD).

This is an iron bridge, and was built in 1876.

The wood-work and sidewalks are in poor condition. The recommendation of previous years is renewed, that the bridge be made to conform to a better street profile.

WEST CHESTER PARK BRIDGE (OVER BOSTON & PROVIDENCE RAILROAD).

This is an iron bridge, and it was built in 1876.

It has been painted, and is in good condition.

WEST RUTLAND SQUARE FOOT-BRIDGE (OVER BOSTON & PROVIDENCE RAILROAD).

This is an iron bridge; it was built in 1882, and is in good condition.

WINTHROP BRIDGE (FROM BREED'S ISLAND TO WINTHROP).

This is a pile bridge without a draw; it was originally built in 1839, was rebuilt in 1851, and was extensively repaired in 1870.

The piles have been reduced in size by the limnoria, and the superstructure is weakened by age. The bridge will need rebuilding in a few years, and when rebuilt, a considerable part of its length can probably be filled solid.

II. — BRIDGES OF WHICH BOSTON SUPPORTS THE PART WITHIN ITS LIMITS.

*CAMBRIDGE-STREET BRIDGE (FROM BRIGHTON TO CAMBRIDGE).

This is a wooden pile bridge with a wooden leaf draw. It was rebuilt in 1884, and is in good condition. The Legislature has ordered the water-way to be widened. (See report to Mayor, Sept. 25, 1888. Appendix A, Doc. 117, 1888.)

CENTRAL-AVENUE BRIDGE (OVER NEPONSET RIVER, DORCHESTER LOWER MILLS).

This is an iron bridge, and was built in 1876.

Part of the roadway has been sheathed, and the bridge is in fair condition.

*CHELSEA BRIDGE NORTH (FROM MYSTIC-RIVER CORPORATION WHARF TO CHELSEA).

The original structure was built in 1802–3; the present structure was built in 1880, except the draw, which was built in 1873.

This is a wooden pile bridge with a wooden draw on a pile foundation. The piles under the draw have been examined by a diver and found in good condition.

The draw was built before the structure came into the charge of the city, and shows evidence of age. It is in safe condition for the present, but will last only a few years more. It will require repairs during the coming year. The fixed part of the bridge is in fair condition.

*ESSEX-STREET BRIDGE (FROM BRIGHTON TO CAMBRIDGE).

This is a wooden pile bridge with a wooden leaf draw, and was originally built in 1850. It was repaired last year, and is in fair condition. The Legislature has ordered the water-ways of the draw made 36 feet wide in the clear. The City of Boston maintains one-half of the draw. (See report to the Mayor, Sept. 25, 1888. Appendix A, Doc. 117, 1888.)

*GRANITE BRIDGE (FROM WARD 24 TO MILTON).

This bridge was originally built in 1837. It is a wooden pile bridge with a wooden leaf draw. The water-way of the draw is ordered widened to 36 feet by the Legislature. The bridge is in fair condition. (See special report to Mayor, Sept. 25, 1888. Appendix A, Doc. 117, 1888.)

LONGWOOD-AVENUE BRIDGE (FROM WARD 22 TO BROOKLINE).

The present structure was built in 1877. This is a wooden bridge, on wooden posts set in the ground. It is a poor bridge, and is only in passable condition. The construction of the Riverdale park will doubtless lead to the building of a new bridge of an entirely different character.

MATTAPAN BRIDGE (FROM WARD 24 TO MILTON).

This is an iron bridge. The bridge, abutments, and centre pier are all in poor condition, and it should be rebuilt. The bridge has been put in safe condition for travel.

MILTON BRIDGE (FROM WARD 24 TO MILTON).

The original structure is very old; it was widened in 1871–72. The older part of this bridge was built of stone, and the widening is an iron structure on stone columns. The sidewalk has been rebuilt. The bridge should be examined and repaired during the low stage of water next summer. No change has been observed in the old stone-work.

*NEPONSET BRIDGE (FROM WARD 24 TO QUINCY).

The original structure was built in 1802, and the present structure was built in 1877. This bridge is a wooden pile bridge with an iron leaf draw; both leaves of the draw are maintained by Boston. It is one of the draws to be rebuilt by order of the Legislature. The bridge is in fair condition. (See report to Mayor, Sept. 25, 1888, Appendix A, Doc. 117, 1888.)

*NORTH BEACON-STREET BRIDGE (FROM BRIGHTON TO WATERTOWN).

This is a wooden pile bridge with a wooden leaf draw. The original structure was built in 1822, and the present structure in 1884.

It is in good condition.

*NORTH HARVARD-STREET BRIDGE (FROM BRIGHTON TO CAMBRIDGE).

This bridge was originally built in 1662, and was rebuilt in 1879.

It is a wooden pile bridge with a wooden leaf draw, and is ordered widened by the Legislature. The abutment is poor; otherwise the bridge is in good condition. (See report to Mayor, Sept. 25, 1888. Appendix A, Doc. 117, 1888.)

SPRING-STREET BRIDGE (FROM WARD 23 TO DEDHAM).

This is a stone bridge, and it is in good condition.

*WESTERN-AVENUE BRIDGE (FROM BRIGHTON TO CAMBRIDGE).

The original structure was built in 1824; the present structure was built in 1879–80.

It is a wooden pile bridge with a wooden leaf draw, and is ordered widened by the Legislature.

It is in fair condition.

(See report to Mayor, Sept. 25, 1888. Appendix A, Doc. 117, 1888.)

*WESTERN-AVENUE BRIDGE (FROM BRIGHTON TO WATERTOWN).

This is a wooden pile bridge. It was built in 1824, the present draw was built in 1883, and the abutment was rebuilt in 1886. It is in good condition.

III. — BRIDGES OF WHICH BOSTON PAYS A PART OF THE COST OF MAINTENANCE.

ALBANY-STREET BRIDGE (OVER BOSTON & ALBANY RAILROAD).

The original structure was built in 1856–57; was rebuilt in 1867–68, and again in 1886–87.

It is an iron bridge, and is in good condition.

*CANAL BRIDGE (FROM BOSTON TO CAMBRIDGE).

*PRISON-POINT BRIDGE (FROM CHARLESTOWN TO CAMBRIDGE).

*WEST BOSTON BRIDGE (FROM BOSTON TO CAMBRIDGE).

These bridges are in the care of two commissioners, appointed, one from Boston and one from Cambridge, and the expense of maintenance is borne equally by each city. The Boston commissioner makes an annual report in print.

Canal bridge is a wooden pile bridge with a wooden turntable draw. The bridge was originally built in 1808; was rebuilt in 1852, and again rebuilt and widened in 1874; some of the piles in this bridge date from 1808. The piles have been examined by the diver and found to be in good condition below low water; above that point they are in only passable condition, and not much dependence is to be placed upon the oldest piles. The draw is in fair condition; the paving and part of the floor is in poor condition.

Prison-point bridge was originally built in 1833, and the present structure was built in 1876–77. It is a wooden pile bridge with an iron leaf draw. The structure is in good condition.

West Boston bridge was built in 1792–93, was rebuilt in

1854, and repaired in 1871; the draw was rebuilt in 1875, and the down-stream sidewalk on the Cambridge side of the draw was rebuilt in 1886.

It is a wooden pile bridge with a wooden turn-table draw. It is old, narrow, and some parts of it are in bad condition; portions of it have been repaired, and the other portions are in need of repairs, which it is expected will be made this year.

Dorchester-street Bridge (over Old Colony Railroad).

This is an iron bridge; it was built in 1869.

It is not in first-class condition, having suffered to a considerable extent from corrosion. It has been sheathed. The wood-work should be removed, and the iron-work examined, cleaned, and painted.

IV. — BRIDGES SUPPORTED BY RAILROADS.

Centre and Mt. Vernon-street bridge, over the Dedham branch, Providence division, Old Colony Railroad, is in process of rebuilding, and plans have been submitted for approval for rebuilding Tremont-street bridge over the Boston & Albany Railroad; Washington-street bridge, over the same road, is in poor condition.

The other bridges given in the list of those supported by railroad corporations require no special mention.

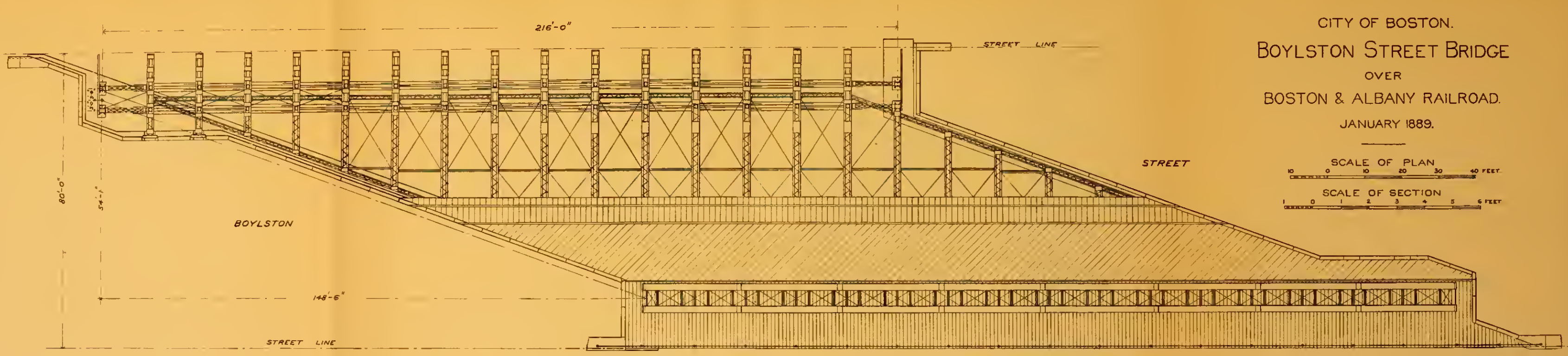
CITY OF BOSTON.

BOYLSTON STREET BRIDGE
OVER
BOSTON & ALBANY RAILROAD.

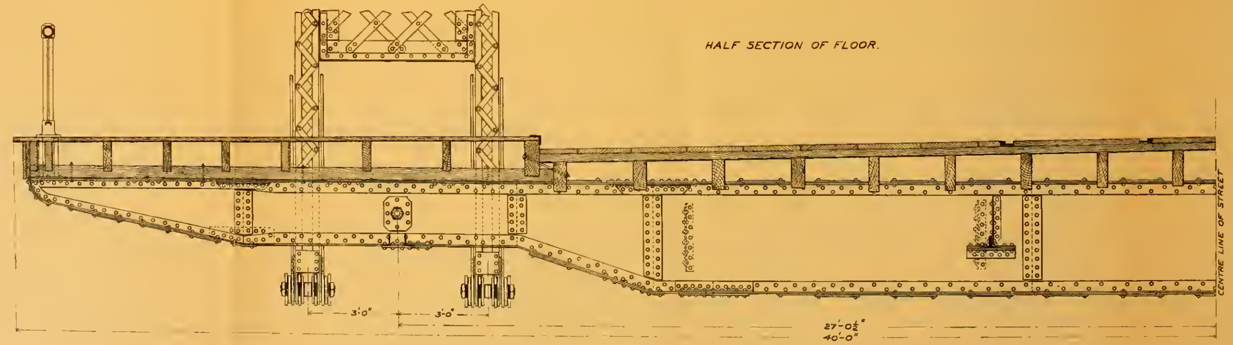
JANUARY 1889.

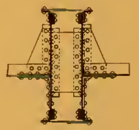
SCALE OF PLAN

SCALE OF SECTION



HALF SECTION OF FLOOR.





SECTION.

Heliotype Printing Co. Bos.

MISCELLANEOUS WORK AND CONSTRUCTION IN 1888.

BOYLSTON-STREET BRIDGE (OVER BOSTON & ALBANY RAILROAD).

The superstructure of this bridge, with the exception of an iron railing for it and its approaches, was completed in September last.

The angle at which Boylston street crosses the Boston & Albany Railroad is such that while the railroad location is but 60 feet wide, the distance across this location, measured on the centre line of the street, is 176.34 feet.

As no part of the railroad location was available for piers, nor for erecting falsework, it was necessary to make the bridge in one span, and provide for its erection by other than the usual methods.

A general plan of the bridge and a section of the floor is shown on the accompanying plate.

The width of the street is 80 feet, and this width on the bridge is divided by two trusses into one roadway and two overhanging sidewalks. The trusses are placed 54 feet 1 inch apart on centres, are alike in design and detail, and are each made of a pair of trusses so connected together as to form a complete truss, requiring no overhead bracing for its lateral support.

The length of main truss is 216 feet between centres of end piers, this length being divided into sixteen panels of 13 feet 6 inches each. Depth of truss between upper and lower chord pins varies from 9 feet 4 inches at ends, to 24 feet at middle. The pair of trusses composing each main truss are placed 6 feet apart on centres.

The following parts of the trusses were made of steel: upper chords, end-posts, all eye-bars 4 inches wide and over, chord-pins, and rollers. All other parts of the trusses, and the entire floor and lateral systems, are made of iron.

Floor-beams are double-plate girders, latticed and tied together on top and bottom flanges. The connection of floor-beams to trusses are so designed as to distribute the loads from beams equally to both halves of the main trusses, and are made by pins passing through the beams and small girders connecting double posts of trusses.

Roadway and sidewalk stringers are hard pine; under course of roadway plank is 3-inch clear hard pine, planed on one side to an even thickness; upper course of roadway plank is 2-inch spruce; and sidewalk plank is 1½-inch clear hard pine, 6 inches to 7 inches wide, planed on one side, and jointed. The steel used in the bridge was required to show a tensile strength of from 62,000 to 70,000 pounds per square inch, an elastic limit not less than 35,000 pounds per square inch, an elongation in 8 inches of not less than 22 per cent, and a reduction of area at point of fracture of not less than 45 per cent.

Each cast of steel made at the mills was tested, and tests were made of the finished steel made from each cast. Four eye-bars, selected at random from those made for the bridge, were tested to breaking, with the following results: —

SIZE OF BAR.	5 × 1.	6 × $1\frac{1}{8}$.	6× $1\frac{1}{2}$.	4 × $\frac{3}{4}$.
Length, back to back, of pin-holes	13.89′	13 89′	13.89′	27.5′
Elastic limit, pounds per square inch	44,390	36,460	36,520	38,210
Tensile strength, pounds per square inch	65,110	61,870	58,770	62,420
Elongation, per cent. in 12 feet	18.1	19.	14.9	
Elongation, per cent. in 26 feet	. . . . . .	. . . . . .	. . . . . .	13.
Reduction of area at fracture, per cent.	46.	49.4	50.	55.

All iron used in the bridge was tested and inspected at mills.

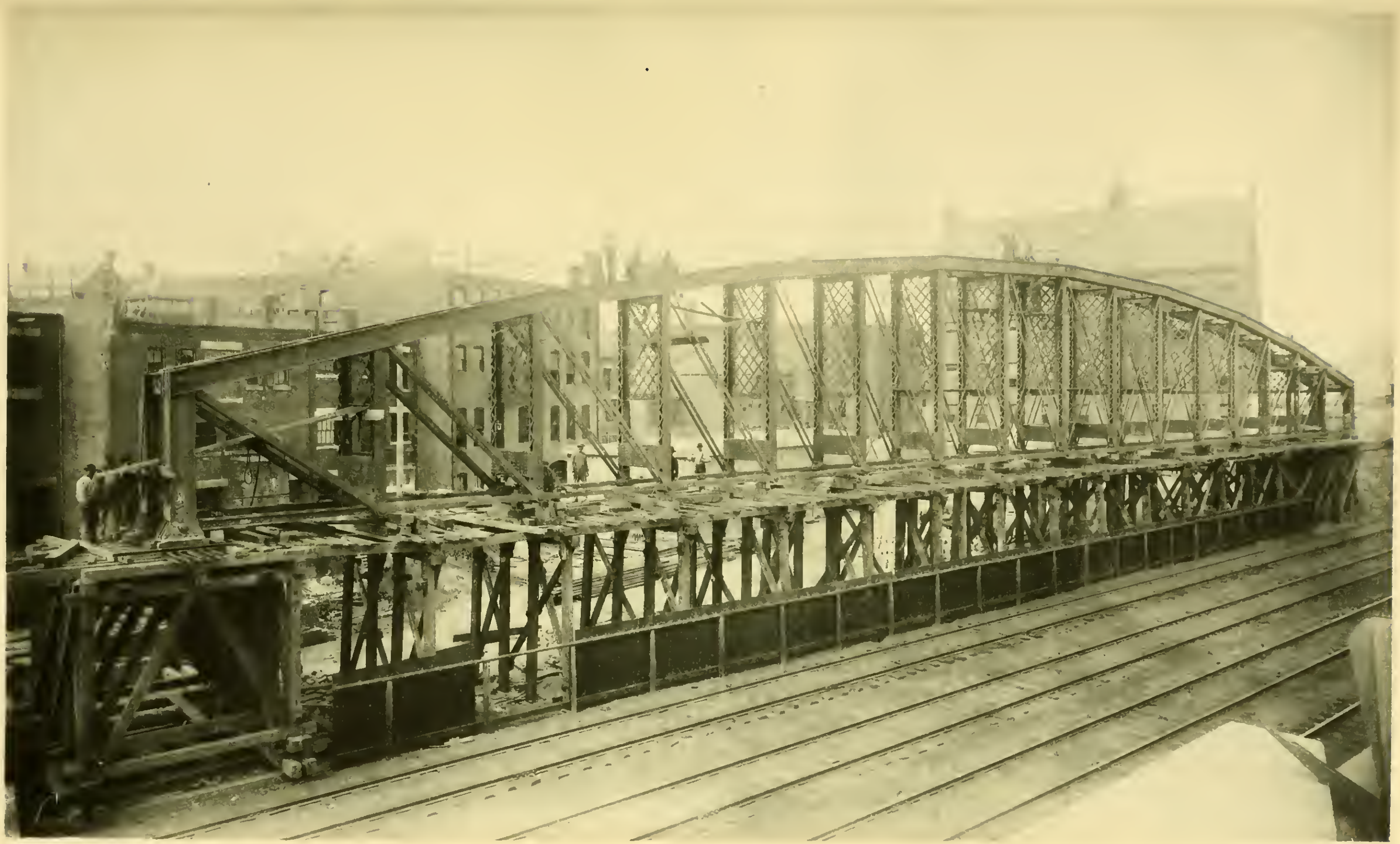
The steel for the work was made by Carnegie, Phipps, & Co., Pittsburgh, Penn., and the inspection and testing of the iron and steel was done by the Pittsburgh Testing Laboratory.

The steel eye-bars were manufactured by the Edge Moor Iron Company, Wilmington, Del.

Several methods of putting the main trusses of the bridge in place, without the use of falseworks in the railroad location, were considered; but the railroad officials having consented to allow their tracks to be occupied by movable falseworks for a few hours on Sunday mornings, the contractor was enabled to carry out the plan devised and preferred by him.

Each truss was erected on a staging at the side of, and parallel to, the railroad, one end of the truss resting on an abutment, and the other end on a timber horse or tower. Between the truss-shoe and the top of the tower were placed iron rollers, working between bars of railroad iron, and underneath the tower were wooden rollers, resting on timber sills.

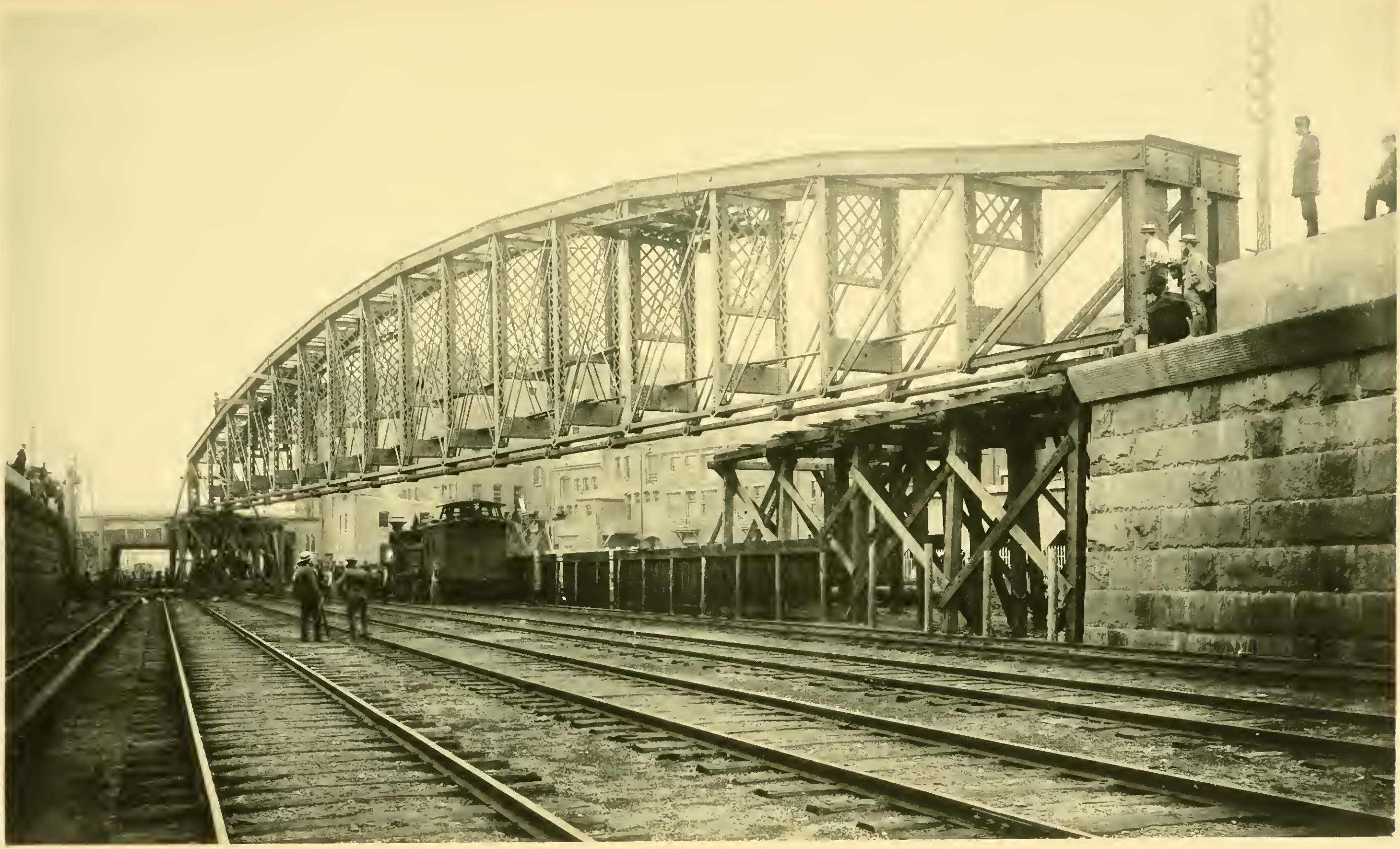
When the truss was connected, its abutment end was placed upon an hydraulic jack, and the tower end swung about



HELIOTYPE PRINTING CO.
BOSTON MASS.

BOYLSTON STREET BRIDGE

216 FT. TRUSS ON STAGING.



HELIOTYPE PRINTING C

BOSTON MASS.

BOYLSTON STREET BRIDGE.

Swinging 216 ft. Truss Across Tracks.

this jack as a pivot, to the opposite abutment, the tower moving, by means of the wooden rolls, on sills laid across the railroad tracks.

When the tower had reached the abutment, the top of the tower was adjusted to the proper level by means of jacks, and the end of the truss moved on the iron rolls and railroad iron from the tower to its proper place on the abutment.

The trusses were swung into place on the mornings of July 22 and 29, respectively, about four hours being taken each morning for doing the work, including time spent in waiting for the arrival and passage of trains on the tracks crossed.

The accompanying photographic views will serve to illustrate the previously described method of placing the trusses.

The design and detail plans for the bridge were prepared in this department, and the work of building and erecting the bridge was done by the Boston Bridge Works, the price paid under the contract being $46,490.90.

BOYLSTON-STREET BULKHEAD.

Plans and specifications were prepared for building a wooden bulkhead and sidewalk opposite the land of an abuttor, between the bridge over the railroad and West Chester Park. The work was done by contract at a total cost of $2,197.42, and was completed in October.

CHARLES RIVER AND NEPONSET RIVER BRIDGES.

Estimates and reports have been made of the cost of compliance with the requirement of the Legislature for widening the water-ways of six (6) bridges, four on the Charles and two on the Neponset river.

Orders have been issued by the Secretary of War, under the provision of the last River and Harbor Bill, passed by Congress, requiring the rebuilding of the four highway and five railroad bridges nearest the mouth of the Charles river.

The water-ways of the only remaining railroad bridge and of the four next highway bridges have been ordered widened by the State Legislature, and it is understood that petitions will be presented to include the two remaining highway bridges below the head of navigation at Watertown.

Every bridge on the river, with the exception of the new Harvard Bridge (yet unfinished), requires extensive changes to fit it for purposes of navigation, as contemplated in the above-mentioned orders. During the last session of the Legislature, an order was introduced for an inquiry by the

Harbor Commissioners into the expediency of closing the river to vessels with masts. The order was favored by the city, passed in committee, but failed to pass the House. Eleven highway bridges would be affected by the order; of these, the city of Boston supports the two most important, and pays half the cost of maintaining the remainder.

The City Council has already voted to petition Congress with reference to the city bridges affected by the order of the Secretary of War; and in view of the facts above stated, it is suggested that the inquiry into the merits of the case and the collection of statistics should be made.

CRISPUS ATTUCKS MONUMENT.

On Oct. 1, 1888, a contract was made with Robert Krause, the designer of the monument, to furnish and erect its foundation and pedestal for the sum of $300 for the foundation and $1,650 for the pedestal. The whole work was done as agreed, so as not to delay the formal dedication of the monument.

D STREET, SOUTH BOSTON.

A special report was made to the City Council, Nov. 22, 1888, upon means for abating a nuisance caused by the low grade of this street where it passes under the Old Colony Railroad.

EAST BOSTON FERRIES.

The work of rebuilding the slips of the South Ferry, East Boston side, in progress at the date of the last annual report, was completed in February, and cost $13,487.38.

FEDERAL-STREET BRIDGE.

A special report was made upon the dangerous condition of this bridge on Oct. 8, 1888, and an estimate presented for rebuilding it.

TESTS OF GASKILL PUMPING–ENGINES AT CHESTNUT HILL.

On August 9, 10, August 22, 23, and September 26, 27, tests were made to ascertain the duty of the new high-service pumping-engines at Chestnut Hill, and also to determine the efficiency of the boilers connected with them.

The engines are of the type known as the Gaskill Horizontal Pumping-Engine, and were built by the Holly Manufacturing Co. of Lockport, N.Y.

The general specifications under which bids were received were prepared by the City Engineer, in June, 1886, and the following extracts from them will show the capacity and duty required of the engines, and the methods prescribed for ascertaining the same: —

The engines are each to have sufficient capacity to easily deliver into the Fisher-Hill reservoir, so called, eight million (8,000,000) U.S. gallons of water per twenty-four hours, the total lift being from 116 to 128 feet.

The loss of action in the pumps must not exceed 4 per cent.

The piston speeds per minute, for the above-named capacities, are not to exceed, for direct-acting engines, one hundred and ten (110) feet, and for beam and fly-wheel engines (vertical), two hundred (200) feet.

As the efficiency of the engines is required to be shown independently of that of the boilers, the calculation of the required duties of the engines will be based upon a unit of water evaporated into dry steam in the boilers, the equivalent of which shall be eleven hundred (1,100) pounds of water evaporated from and at 212 degrees Fahrenheit.

Each engine will be required to exhibit a duty of one hundred million (100,000,000) foot-pounds per before specified unit of water evaporated into dry steam in the boilers.

The duty trials, one for each engine, will be conducted in the following manner: steam will be raised in the boilers to the lowest pressure at which the engines will run at full speed for capacity, when the fires will be hauled, the furnaces and ash-pits cleaned, and fresh fires started with as little delay as possible. As soon as the fires are well ignited the engine will be started and run at full speed for capacity, with the working pressure of steam, for twenty-four hours. At the latter part of the trial the fires will be burned down until the steam-pressure in the boilers is the same as at the beginning of the trial, when the engine will be stopped. The amount of water in the boilers is to be the same at the end as at the commencement of the trial. During the trial the pressure and temperature of the steam, and the temperature and weight of water supplied to the boilers, will be carefully noted. Calorimeter tests will be made to determine the quality of the steam supplied to the engines, and steam containing not more than 3 per cent. of entrained water will be considered dry steam.

The duty of the engine will be computed as follows: the area of the plunger in feet will be multiplied by the pressure in pounds, due to the total lift in feet, which will be obtained from the average reading of a correct pressure-gauge, attached to the force-main, near its connection to the pump, to which will be added the pressure due to the difference of level between the zero of the gauge and the water in the pump-well; the product thus obtained will be further multiplied by the total number of feet travelled by the plungers on their discharging strokes. This product equals the total work in foot-pounds. The amount of water evaporated by the boilers during the trial will be reduced to an equivalent number of pounds of water evaporated from and at 212 degrees Fahrenheit. The total work in foot-pounds divided by this equivalent evaporation, and the quotient multiplied by 1,100, will be the duty of the engine in foot-pounds, per specified unit of water evaporated into steam. All steam used for feed-pumps, condensers, and other appliances will be taken from the boiler furnishing steam to the engine, and no allowances will be made for steam so used.

The efficiency of the boilers will be tested at the duty trials.

Capacity tests of the engines will be made either in conjunction with the duty trials or separately; the amount of water pumped to be determined by weir-measurement at the Fisher-Hill reservoir.

The duty trials will be conducted by the City Engineer, and the expense of them will be borne by the City.

The Contractor, or his representatives, may be present at the duty and capacity trials of the engines, and may have access to all instruments used and notes taken.

The water fed to the boilers included water from the force main and the condensed water from the cylinder jackets, and was weighed in a barrel placed upon a tested platform scale. After weighing, the water was run into a large tub, from which the feed-pumps were supplied. In the test of Engine No. 1, a Knowles feed-pump was used for pumping the feed-water, and in the test of Engine No. 2, a feed-pump on the engine was used. The measurement of the feed-water was checked by a Worthington meter placed in the boiler feed-pipe.

The approximate quantity of water returned from the cylinder jackets was obtained by metering the supply from the force main, and subtracting this amount from total amount of feed-water used.

The tests were made under the direction of the City Engineer, and care was taken to secure accuracy in all observations. The observers were divided into night and day parties, and the more important readings were taken independently by two persons. The tests were under the immediate supervision of Mr. John E. Cheney, Assistant City Engineer, and Mr. Dexter Brackett, Supt. Eastern Division Boston Water Works, the former taking charge of the night party, and the latter the day party. Asst. Engineer John A. Gould acted as principal assistant to the above mentioned.

Calorimeter tests of the steam were made during the first and second tests by Mr. George H. Barrus, M.E. On account of the dryness of the steam shown by these tests, and the large amount of steam used in making them, it was not considered advisable to continue these tests at the third trial.

The weir-measurements at Fisher-Hill reservoir were made under the direction of Mr. Desmond FitzGerald, Resident Engineer and Supt. Western Division Boston Water Works.

It will be noted that, in accordance with the specifications, the duty of the engines was to be computed upon a unit of steam used by them, instead of upon the usual unit of coal burnt under the boilers. The duty of the engines was therefore to be shown in terms of heat furnished to, and consumed by them. The unit of steam used was made large, and consequently no allowances were made for any steam not used by the engine proper, nor for any heat returned from the engine to the boiler.

The duty required by the specifications can be expressed in general terms as, —

Duty per 1,100 lbs. water evaporated from and at 212°

$$=\frac{\text{Work done in ft.-lbs.} \times 1{,}100.}{\text{Equivalent lbs. of water evaporated from and at } 212^\circ.}$$

At the trial of Engine No. 2, made on September 26, 27, the work done was 8,754,116,000 ft.-lbs., and the weight of water fed to the boiler and evaporated into steam at 79.9 lbs. pressure, was 88,453 lbs. The equivalent evaporation from and at

$$212^\circ \text{ was } 88{,}453 \times \frac{1{,}000}{966} = 91{,}566.25 \text{ lbs.}$$

Then, —

Duty per 1,100 lbs. water evaporated from and at 212°

$$=\frac{8{,}754{,}116{,}000 \times 1{,}100}{91{,}566.25} = 105{,}164{,}600 \text{ ft. lbs.}$$

The specified unit of water evaporated into steam equals 1,100 pounds of steam made from and at 212°, and this can be expressed by the 1,062,600 heat units contained therein. By adapting the formula to this expression of the specified unit, it becomes general in character and application, and appears in the following form : —

Duty per 1,100 pounds steam made from and at 212°.

$$=\frac{W \times 1{,}062{,}600}{U - u} \text{ in which}$$

W = Work done by engine in ft.-lbs.

U = Heat units in total steam used, in excess of heat units in equal weight of water at 212°.

u = (1st) Heat units returned from engine to boiler, plus (2d) heat units in steam used for any purpose other than running the engine, in excess of heat units in equal weight of water at 212°.

The duty of engine No. 2, as per trial of September 26, 27, is shown by the formula as follows :—

Duty per 1,100 pounds steam made from and at 212°

$$=\frac{8{,}754{,}116{,}000 \times 1{,}062{,}600}{88{,}453 \times 1{,}000} = 105{,}164{,}600 \text{ ft. lbs.,}$$

the same result as obtained by the specified formula.

In the above-mentioned trial the heat of the feed-water was increased 38.9° by the addition of the jacket-water, and the amount of heat returned to boiler from engine therefore equals 88,453 × 38.9 = 3,440,821.7 heat units. The net duty of engine per 1,100 pounds steam made from and at 212° then equals $\frac{8{,}754{,}116{,}000 \times 1{,}062{,}600}{88{,}453{,}000 - 3{,}440{,}821.7} = 109{,}421{,}100$ ft.-lbs.

In case calorimeter tests of the steam had been made, "u" would have been increased by the addition of the heat units contained in steam used for the tests, in excess of heat units in equal weight of water at 212°.

Record of Duty Trials of Two Gaskill Horizontal Compound Pumping-Engines, at Chestnut-Hill Pumping-Station, Boston Water Works.

		Engine No. 1.	Engine No. 2.
1	Date of trials	Aug. 9–10, 1888.	Sept. 26-27, 1888.
2	Time of beginning	10.22 A.M.	9.50 A.M.
3	Duration	23 h. 51 m.	24 h. 11 m.
4	Total revolutions	27,402.5	28,316
5	Revolutions per minute	19.15	19.51
6	Net area of pump plunger	3.3652 sq. ft.	3.3652 sq. ft.
7	Length of stroke per revolution (3 ft. × 4)	12 ft.	12 ft.
8	Grade of water in pump well	123.14 "	123.38 "
9	Pressure in force main reduced to grade in ft. by mercury gauge	245.59 "	246.14 "
10	Total lift in ft.	122.45 "	122.76 "
11	Total lift reduced to pounds	52,972. lbs.	53,165 lbs.
12	Total weight of water evaporated in boilers	86,788.5 "	88,453 "
13	Equivalent weight of water evaporated from and at 212°	89,843 "	91,566.3 "
14	Steam pressure in boilers	79.5 "	79.9 "
15	Duty of engines as developed by trials: —		

$$= \frac{\text{Work done in-foot lbs.}}{\text{Equivalent water evaporated from } 212^\circ} \times 1{,}100$$

$$\text{No. 1} = \frac{27{,}402.5 \times 3.3652 \times 12 \times 52.972 \times 144}{86{,}788.5 \times \frac{1000}{966}} \times 1{,}100 = 103{,}347{,}500.$$

$$\text{No. 2} = \frac{28{,}316 \times 3.3652 \times 12 \times 53.165 \times 144}{88{,}453 \times \frac{1000}{966}} \times 1{,}100 = 105{,}164{,}600.$$

Record of Duty Trials. — Concluded.

		Engine No. 1.	Engine No. 2.
16	Mean vacuum in condenser	26.3 ins.	26.53 ins.
17	Mean atmospheric pressure by barometer..........	30.4 "	29.35 "
18	Mean temperature of air in engine-room	79° F.	70.3° F.
19	Mean temperature of external air . ..	75.1° F.	60.8° F.
20	Total volume of water pumped by plunger displacement, gallons	8,275,555	8,551,432
21	Total volume of water pumped by weir-measurement, gallons...	8,112,725	8,377,000
22	Average slip of pumps..............	2%	2%
23	Indicated horse-power as determined by two sets of cards for each trial..	210.7	214.4
24	Horse-power in water lifted, pump-measurement, no allowance for slip.	178.66	182.76
25	Work done by pumps in per. cent. of indicated horse-power.............	84.79%	85.24%
26	Temperature of feed-water from force main	72.5	61.2
27	Temperature of feed-water after receiving jacket-water..............	104.95	100.1
28	Per centage of feed-water from jackets	13.0%	15.9%
29	Amount of feed-water received from jackets	12,281 lbs.	14,064 lbs.

The boilers used in connection with the engines are of the horizontal, return-tubular type, with external furnaces. They are 78 inches in diameter, 17 feet 11⅛ inches long between tube sheets, and each boiler contains 151 tubes, 3 inches outside diameter.

Shells of boilers are $\frac{7}{16}$-inch thick steel, single-riveted in roundabout seams, and double-riveted in horizontal seams. Tube sheets are ½-inch thick steel. All rivet-holes were punched ⅛-inch small, and reamed to size required for ⅞-inch diameter rivets.

A feed-water heater is located in the smoke-flue between the boilers. It is made of 80 brass tubes, each 2½ inches diameter, and 15 feet long, supported in racks on a portable carriage.

Samples of each sheet of steel used in the boilers were tested for tensile strength, elastic limit, and elongation.

The steel was made by Carnegie, Phipps, & Co., of Pittsburgh, Pa., and was inspected and tested by G. W. G. Ferris, Jr., C.E. of the same city.

The boilers were built by George Miles of Boston, and the flue feed-heater was made by the Atlantic Works of East Boston.

The designs for the boilers and flue-heater were furnished by the City Engineer.

Record of Tests of Two Boilers at Chestnut Hill Pumping-Station, Boston Water Works.

		Boiler No. 2.	Boiler No. 1.
1	Date of trials	Aug. 9–10.	Sept. 26–27.
1a	Time of beginning of trial	10.08 A.M.	9.30 A.M.
2	Duration of trial	24 h. 5 m.	24 h. 36 m.
	Dimensions and Proportions.		
3	Grate surface	38.5 sq. ft.	49 sq. ft.
3a	Area of least draught	6 " "	6 " "
4	Water-heating surface	2,164 " "	2,164 " "
5	Superheating surface	7 " "	7 " "
5a	Heating surface in feed-water heater	931 " "	931 " "
6	Ratio of water-heating surface to grate surface	56:1	44:1
	Average Pressures.		
7	Steam pressure in boiler by gauge	79.5 lbs.	79.9 lbs.
8	Absolute steam pressure	94.2 lbs.	94.3 lbs.
9	Atmospheric pressure by barometer	30.04 ins.	29.35 ins.
	Average Temperatures.		
11	External air	73° F.	56° F.
13	*Steam	326.2° F.	*
14	Escaping gases before passing feed-water heater	358° F.	399.8° F.

*Steam thermometer proved to be incorrect, and was broken while being tested for correction.

Record of Tests of Two Boilers.— Continued.

		Boiler No. 2.	Boiler No. 1.
14a	Escaping gases after passing feed-water heater	208.5° F.	256.5° F.
15	Feed-water before passing heater ...	104.95° F.	100.1° F.
15a	Feed-water after passing heater	153.65° F.	163.2° F.
15b	Cochituate water from force main ...	72.4° F.	61.2° F.
	Fuel.		
18	Coal consumed	9,446 lbs.	9,266 lbs.
19	Total refuse dry {No. 1, 486.5 lbs. No. 2, 900 lbs.}	9.5%	5.3%
20	Total combustible (weight of coal, item 18; less refuse, item 19)....	8,546 lbs.	8,779.5 lbs.
21	Coal consumed per hour	392.2 "	376.7 "
22	Combustible consumed per hour	354.9 "	356.9 "
	Water.		
26	Total weight of water pumped into boiler and apparently evaporated ..	86,788.5 "	88,453 "
26a	Check on above measurement by meter measurement	84,848 "	87,606 "
26b	Per cent. less by meter	2.2	1.0 "
26c	Feed-water taken from force main by meter measurement	75,486 lbs.	74,831 "
28	Equivalent water evaporated into dry steam from and at 212° F.	99,459.6 lbs.	101,897.9 "
	{Including feed-water heater	95,121.2 "	96,060 "
	{Excluding " " "		
29	Equivalent total heat derived from fuel in British thermal units		
	{Including feed-water heater	96,074,870	98,350,891
	{Excluding " " "	91,856,948	92,769,506
30	Equivalent water evaporated into dry steam from and at 212° F. per hour		
	{Including feed-water heater	4,130 lbs.	4,142 lbs.
	{Excluding " " "	3,950 "	3,905 "

Record of Tests of Two Boilers. — Continued.

			Boiler No. 2.	Boiler No. 1.
	Economic Evaporation.			
31	Water actually evaporated per lb. of coal, from actual pressure and temperature		9.19 lbs.	9.55 lbs.
32	Equivalent water evaporated per lb. of coal from and at 212° F.	Including feed-water heater	10 53 “	11.00 “
		Excluding “ “ “	10 07 “	10.37 “
33	Equivalent water evaporated per lb. of combustible from and at 212° F.	Including feed-water heater	11.64 “	11.61 “
		Excluding “ “ “	11.13 “	10.94 “
	Commercial Evaporation.			
34	Equivalent water evaporated per lb. of coal, with one-sixth refuse at 70 lbs. gauge pressure, from temperature of 100° F., = item 33 multiplied by .7249 —	Including feed-water heater	8.44 “	8.42 “
		Excluding “ “ “	8.07 “	7.93 “
	Rate of Combustion.			
35	Coal actually burned per sq. ft. of grate surface per hour		10.19 “	7.69 “
36	Consumption of dry coal per hour. Coal assumed with one-sixth refuse.	Per sq. ft. of grate surface	11.07 “	8.78 “
37		Per sq. ft. of water-heating surface	.197 “	.198 “
38		Per sq. ft. of least draught	71.01 “	71.7 “
	Rate of Evaporation.			
39	Water evaporated from and at 212° F. per sq. ft. of water-heating surface per hour, excluding feed-water heater		1.83 “	1.80 “
40	Water evaporated per hour from temperature of 100° F. into steam of 70 lbs. gauge pressure, excluding feed-water heater.	Per sq. ft. of grate surface	89.3 “	69.3 “
41		Per sq. ft. of water-heating surface.	1.59 “	1.57 “
42		Per sq. ft. of least area for draught.	573 “	566.3 “

Log of Test of Engine No. 1 and Boiler No. 2 at Chestnut Hill Pumping-Station, Boston, Aug. 9-10, 1888.

	GAUGES.								TEMPERATURES.											QUANTITY OF WATER FED TO BOILER.									WATER EVAPORATED.		
																				Meter Measurement used as Check on Weighing.				By Weighing.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Time	Engine counter.	Revolutions of engine.	Mercury gauge on force main of engine.	Float-gauge showing level of water in pump-well of engine.	Steam in boiler.	* Steam at engine.	Vacuum in condenser.	Atmospheric pressure by barometer near engine.	† Steam near boiler.	Feed-water before passing heater.	Feed-water after passing heater.	Escaping gases before passing feed water heater.	Escaping gases after passing feed-water heater.	Air near engine.	External air.	Feed-water before receiving jacket-water.	Feed-water after receiving jacket-water.	Coal fed to boiler, including 40% of wood.	Amount of steam used by calorimeter.	Reading of feed-water meter.	Cubic feet per 30 minutes.	Pounds per 30 minutes.	Total amount fed to boiler from the beginning of the test.	Amount of cold feed-water.	Amount of water from steam-jackets.	Quantity weighed and emptied into feed-tub.	Quantity fed to boiler per 30 minutes, corrected meter readings.	Total amount fed to boiler from the beginning of the test.	Height of water in boiler above bottom of glass gauge.	Quantity of water in boiler above assumed datum.	Evaporation per 30 minutes.
Aug. 9.			Feet above W. W. Base.	Feet above W. W. Base.	Lbs.	Lbs.	Inches.	Inches.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Lbs.	Lbs.	Cubic feet.	Cubic feet.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Inches.	Lbs.	Lbs.
10.08 a.m.	595,792	.....	238.70	123.71	68¾	68.9	...	30.00	...	105½	160	....	....	81	Regular readings of thermometer not taken. Average obtained from a recording and a maximum and minimum thermometer.	....	....	.....	See report on Calorimeter Test.	67,707½	....	.....	.....	.....	Total amount = column 27 less column 25.	.....	.....	.....	4¾	1,030	.....
10.22 "	595,792	146	244.48	122.60	77½	78.0	...	....	323	112	....	276	202	....		....	....	.....		......	3.5	217	217	249		....	217	217	....	.....	217
10.30 "	595,938	503	246.55	123.04	76½	76.0	26½	30.00	....	97½	189	....	....	81.5		....	80	.....		67,711	31	1,020	2,137	2,367		2,302.5	1,963	2,160	...	.....	1,968
11.00 "	596,536	596	245.60	123.14	79½	79.9	26¼	30.00	326	89	208	324	214	82		72	90	....		67,742	25	1,548	3,685	810		1,281	1,579	3,769	4½	875	1,734
11.30 "	597,132	586	246.00	123.12	80	80.9	26½	30.01	329	105½	156½	....	....	83		....	107	.....		67,767	33	2,044	5,729	1,619		2,262	2,094	5,853	3¾	640	2,429
12.00 m.	597,718	574	245.00	123.18	80	80.4	26¼	30.00	327	104	143	324	204	83.5		72	103	.....		67,800	32	1,982	7,711	2,553		2,164	2,032	7,885	4¾	710	1,962
0.30 p.m.	598,292	678	245.87	123.11	80	80.9	26½	30.00	327	104	149	....	....	85		....	102	.....		67,832	34	2,106	9,817	1,657		1,737.5	2,166	10,041	4½	875	1,691
1.00 "	598,870	587	246.12	123.18	79½	80.4	26½	30.00	326	106	141	322	194	84.6		73	104	.....		67,866	26	1,610	11,427	1,619		2,281.5	1,641	11,682	5	1,075	1,441
1.30 "	599,457	587	246 25	123.07	80	81.4	26½	30.00	328	[illegible]	146	....	....	85		...	105	.....		07,892	20	1,239	12,066	810		649.5	1,264	12,946	4½	875	1,464
2.00 "	600,044	576	245 60	123.13	79½	79.9	26½	29.98	327	110	155	334	197	86.5		72½	111	.....		67,912	30	1,858	14,524	1,432		2,267	1,895	14,841	3 6-16	325	2,445
2.30 "	600,620	580	245.60	123.10	80	81.4	26½	29.97	326	114½	156	....	....	86.5		....	111	.....		67,942	39	2,415	16,939	2,803		2,461	2,471	17,312	3½	425	2,371
3.00 "	601,200	580	246.00	123.10	79½	79.9	26½	29.96	327	99	154½	366	207	88		73	98	.....		67,081	28	1,734	18,673	1,657		1,902.5	1,771	19,083	4¾	925	1,271
3.30 "	601,780	578	246.25	123.06	80	80.9	26½	29.98	326	104	157	...	....	87		....	104	.....		68,009	28	1,734	20,407	1,246		1,386	1,771	20,854	4¼	765	1,931
4.00 "	602,358	571	245.25	123.12	80	80.4	26¼	29.08	326	108	1:3	364	208	87		72½	109	2,685.65		68,037	27	1,672	22,079	1,744		2,114.6	1,709	22,563	4¼	710	1,764
4.30 "	602,929	572	245.37	123.10	79½	80.4	26¼	29.98	326	107	160½	....	....	87		....	108	.....		68,064	26	1,610	23,689	1,931		1,489.5	1,648	24,211	4	650	1,708
5.00 "	603,501	570	245.10	123.12	79½	79.9	26¼	20.98	326	110	166	370	214	87.6		72½	110	.....		68,090	28	1,734	26,423	747		1,604.5	1,771	25,982	3½	425	1,996
5.30 "	604,071	574	245.40	123.12	80	80.4	26½	29.98	326	110	162	....	....	87		....	109	.....		68,118	39	2,415	27,636	2,304		2,457	2,477	28,459	3 5-16	325	2,577
6.00 "	604,645	579	246.00	123.12	79½	79.9	26½	29.98	326	102	151	360	214	87		72½	99	.....		68,157	34	2,106	29,944	1,744		2,502	2,166	30,015	4 5-16	790	1,691
6.30 "	605,224	571	240.00	123.10	79½	79.9	26½	29.98	326	102	150½	....	....	85		....	101	.....		68,191	33	2,044	31,988	1,808		1,592.5	2,094	32,709	6¼	1,125	1,759
7.00 "	605,795	563	245.20	123.12	79½	79.9	20¼	29.98	326	103	146	362	213	83		73½	103	.....		68,224	24	1,480	33,474	1,557		1,960.5	1,517	34,226	5¼	1,370	1,272
7.30 "	606,368	571	245.75	123.00	80	81.4	26¼	30.00	326	103	152	....	....	....		....	104	.....		68,248	21	1,301	34,775	1,121		1,235	1,332	35,558	6¼	1,126	1,577
8.00 "	606,929	567	246.40	123.16	80	80.4	20½	30.00	326	109	168	356	208	82		72	100	.....		68,269	20	1,239	36,014	1,059		1,326	1,264	36,822	4¼	710	1,679
8.30 "	607,496	562	245.10	123.13	80	80.9	26.4	30.00	326	113½	159½	....	....	81		....	118	.....		68,289	36	2,230	38,244	2,429		2,054	2,285	30,107	3	145	2,850
9.00 "	608,058	560	245.00	123.19	80	80.9	26.4	30.00	326	108	160	341	208	82		72½	108	2,344.75		68,326	34	2,106	40,350	1,308		2,162.5	2,155	41,262	4½	765	1,535
9.30 "	608,618	560	245.75	123.16	79½	80.4	26.4	30.00	326	102	150	....	....	82		...	103	.....		68,359	35	2,168	42,518	2,491		2,106	2,224	43,486	5	1,075	1,914
10.00 "	609,187	567	245.80	123.10	80	80.9	26.35	30.00	326	100½	141	348	206	81		72½	101	.....		68,394	27	1,672	44,160	672		2,086	1,709	45,195	0	1,470	1,314
10.30 "	609,754	574	245.20	123.16	80	80.9	26.3	30.02	326	99½	146	....	....	80.5		....	103	.....		68,421	16	991	45,181	623		541	1,016	46,211	5¾	1,370	1,116
11.00 "	610,328	565	246.00	123.15	79½	80.4	26.3	30.02	326	106	155	348	208	80		72½	108	.....		68,437	20	1,239	46,420	1,059		1,465	1,264	47,475	4	650	1,984
11.30 "	610,603	569	245.35	123.14	80½	80.9	20.3	30.03	326	118	160	....	....	79		....	121	.....		68,457	28	1,734	48,154	1,682		1,808	1,771	49,246	3	145	2,270
12.00 "	611,452	559	245.10	123.22	79½	79.9	20.3	30.04	326	115	154	348	206	78		72½	114	.....		68,485	38	2,353	50,507	1,931		2,530	2,409	51,655	3	145	2,409
August 10. 0.30 a.m.	612,011	560	245.50	123.18	80	80.4	26.3	30.04	326	103	153	....	....	77.5		....	102	....		68,523	27	1,072	52,179	1,059		1,446	1,709	53,364	4½	765	1,089
1.00 "	612,571	564	245.40	123.15	80½	81.4	26.3	30.04	327	98	153½	366	210	76.5		72½	99	.....		68,550	34	2,106	54,285	2,553		2,213.5	2,155	55,519	5	1,075	1,845
1.30 "	613,135	556	245.00	123.24	80	80.4	26.3	30.05	327	103½	144	....	....	76		....	104	.....		68,584	26	1,610	55,895	1,495		1,985	1,648	57,167	4¾	975	1,748
2.00 "	613,691	551	245.25	123.20	80½	80.9	26.3	30.05	327	100	145	362	210	75		72½	104	.....		68,610	27	1,672	57,567	1,370		1,408.5	1,709	58,876	5	1,075	1,609
2.30 "	614,242	552	246.33	123.18	80	80.9	26.3	30.06	327	107	140	....	....	73.5		....	109	.....		68,637	26	1,610	59,177	1,183		1,445.5	1,648	60,524	4¼	975	1,748
3.00 "	614,794	569	245.00	123.22	80	80.9	26.3	30.07	327	107½	140	358	206	73.5		72½	100	.....		68,663	26	1,610	60,787	1,432		1,602	1,647	62,171	4¼	975	1,647
3.30 "	615,363	571	246.50	123.13	79	79.9	26.3	30.07	328	107½	161	....	....	73		....	108	2,266.25		68,689	30	1,858	62,645	1,744		2,394	1,902	64,073	4½	875	2,002
4.00 "	615,934	567	245.20	123.24	79½	79.9	26.3	30.08	326	105	153½	374	210	71.5		72½	104	.....		68,719	31	1,920	64,565	810		2,031.5	1,963	66,036	4¾	925	1,913
4.30 "	616,491	573	245.00	123.26	80	80.9	26.3	30.10	327	104	153	....	....	70.5		....	106	.....		68,750	20	1,790	66,361	2,304		1,765	1,833	67,809	5	1,075	1,683
5.00 "	617,064	595	245.75	123.20	79	79.9	26.3	30.11	327	104	148	374	210	70		72½	107	.....		68,779	28	1,734	68,095	1,031		1,609.6	1,771	69,640	5¼	1,125	1,721
5.30 "	617,659	601	246.26	123.13	80	80.9	26.3	30.11	326	104½	149½	....	....	70		....	106	.....		68,807	28	1,734	69,829	1,246		1,479.5	1,771	71,411	4½	975	1,921
6.00 "	618,260	584	246.25	123.11	80	80.9	28.3	30.12	326	105	150	374	210	69		72½	107	.....		68,835	30	1,858	71,687	1,019		1,840	1,901	73,312	4½	975	1,901
6.30 "	618,844	588	245.87	123.10	80	81.4	26.3	30.14	326	107	148½	....	....	69.5		....	100	.....		68,865	32	1,982	73,669	2,180		2,609.5	2,032	75,344	4¼	975	2,032
7.00 "	619,430	592	246.20	123.00	79½	80.4	26.3	30.14	326	103½	148	374	210	69.5		72½	100	.....		68,897	30	1,858	75,527	1,495		1,672	1,901	77,245	5¼	1,125	1,751
7.30 "	620,022	590	245.40	123.16	79	79.9	20.25	30.13	326	103	148½	....	....	71		....	103	.....		68,927	22	1,363	76,890	1,183		1,363	1,393	78,638	5	1,075	1,443
8.00 "	620,612	584	245.75	123.10	80	80.4	26.3	30.13	326	104	154½	376	208	72		72	105	.....		68,949	37	2,291	79,181	1,869		2,584.5	2,347	80,985	4 3-16	735	2,687
8.30 "	621,198	580	245.75	123.11	79	79.9	26.3	30.13	326	108	147½	....	....	72		....	104	.....		68,986	23	1,424	80,605	1,059		858	1,455.5	82,440.5	6 5-16	1,200	990.5
9.00 "	621,778	578	245.30	123.14	79	79.9	26.3	30.13	325	105	151½	382	212	73		72	107	.....		69,009	35	2,168	82,773	2,367		2,630	2,223	84,663.5	4 3-16	736	2,688
9.30 "	622,354	583	246.40	123.07	79½	80.0	26.3	30.13	330	99½	161½	....	....	75.5		....	90	....		69,044	21	1,301	84,074	1,121		1,451	1,332	85,995.5	4½	1,030	1,637
10.00 "	622,937	257.5	245.00	123.06	75½	76.9	26.3	30.16	322	107½	157	380	218	76		72	110	2,149.35		69,065	12.5	774	84,848	374		600	793	86,788.5	4½	1,030	793
10.30 "	623,194.5	.....	245.60	123 40	68½	68.9	...	30.15	....	110½	162	....	....	78		....	.....	....		69,077½	....	.....	.....	....		......	......	......	....	.....	.....
....	......	27,402.5	245.59	123.14	79½	79.0	26.3	30.04	326.2	104.05	153.65	358	208.5	79.0	73	72.4	105.2	9,440.0	1,369.5	.....	1,370.	84,848	.....	75,486	11,302.5	80,788.5	86,788.5	.....	....	.....	86,788.5

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* This steam-gauge apparently reads too high.

† This thermometer apparently reads too high.

Log of Test of Engine No. 2 and Boiler No. 1 at Chestnut Hill Pumping-Station, Boston, Sept. 26-27, 1888.

			GAUGES.						TEMPERATURES.											QUANTITY OF WATER FED TO BOILER.									WATER EVAPORATED.		
																				Meter Measurement used as Check on Weighing.				By Weighing.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Time.	Engine counter.	Revolutions of engine.	Mercury gauge on force main of engine.	Float-gauge showing level of water in pump-well of engine.	Steam in boiler.	Steam at engine.	Vacuum in condenser.	Atmospheric pressure by barometer near engine.	Steam near boiler.	Feed-water before passing heater.	Feed water after passing heater.	Escaping gases before passing feed-water heater.	Escaping gases after passing feed-water heater.	Air near engine.	External air.	Feed-water before receiving jacket-water.	Feed-water after receiving jacket-water.	Coal fed to boiler, including 40% of wood.	Amount of steam used by calorimeter.	Reading of feed-water meter.	Cubic feet per 30 minutes.	Pounds per 30 minutes.	Total amount fed to boiler from the beginning of the test.	Amount of cold feed-water.	Amount of water from steam jackets.	Quantity weighed and emptied into feed-tub.	Quantity fed to boiler per 30 minutes, corrected meter readings.	Total amount fed to boiler from the beginning of the test.	Height of water in boiler above bottom of glass gauge.	Quantity of water in boiler above assumed datum.	Evaporation per 30 minutes.
Sept. 26.			Feet above W.W. Base.	Feet above W.W. Base.	Lbs.	Lbs.	Inches.	Inches.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Lbs.		Cubic feet.	Cubic feet.	Lbs.	Lbs.	Cubic feet.	Cubic feet.	Lbs.	Lbs.	Lbs.	Inches.	Lbs.	Lbs.
9.30 a.m.	....	195	....	....	....	....	....	....	Thermometer incorrect, and was broken while being tested for a correction after this test.	....	....	....	....	....	Regular readings of thermometer not taken. Average temperature obtained from a recording and maximum and minimum thermometer.	....	....	....	None.	113,099	8	496	496	....	....	....	502	502	4⅛	710	502
10.00 "	195	598	246.25	123.04	80.3	79.5	26.6	29.15		88	181	334	228	69		62	103	....		113,107	31	1,922	2,418	....	....	2,135	1,940	2,442	....	....	1,946
10.30 "	793	572	247.25	123.05	80.3	80	26.5	29.13		101	204	....	....	68		....	104	....		113,138	27	1,674	4,092	50	16.7	2,165.5	1,693	4,135	4	650	1,753
11.00 "	1,365	575	246.40	123.43	80.3	80	26.3	29.08		100	158	324	212	67		61½	103	....		113,165	34	2,108	6,200	....	....	855	2,133	6,268	4	650	2,133
11.30 "	1,940	568	245.80	123.46	79.8	81	26.5	29.12		104	154	....	....	68		....	108	....		113,199	18	1,116	7,316	44	12.6	2,436	1,128	7,396	3⅜	360	1,418
12.00 m.	2,508	592	246.25	123.42	80.3	80	26.5	29.11		105	150	314	210	67		61	104	....		113,217	28	1,736	9,052	....	....	1,647.5	1,755	9,151	3⅜	360	1,755
0.30 p.m.	3,100	580	246.40	123.40	80.3	80	26.4	29.12		103	148	....	....	66		....	105	....		113,245	30	1,860	10,912	51	7.6	1,981.5	1,878	11,029	3⅛	220	2,018
1.00 "	3,680	583	246.30	123.41	80.3	80	26.4	29.15		101	146	314	196	70½		61	100	....		113,275	31	1,922	12,834	....	....	1,081.5	1,941	12,970	3¼	290	1,871
1.30 "	4,263	594	246.40	123.41	80.3	80	26.3	29.18		103	142	....	....	71		....	106	....		113,306	29	1,798	14,632	56	10.6	2,602	1,817	14,787	3½	425	1,682
2.00 "	4,857	577	246.30	123.41	80.3	80	26.5	29.25		98	140	318	196	71½		61	102	....		113,335	21	1,302	15,934	....	....	860.5	1,314	16,101	3⅜	360	1,379
2.30 "	5,434	566	245.75	123.45	80.3	79.5	26.5	29.19		102	140	....	....	73		....	108	....		113,356	35	2,170	18,104	47	9.8	2,726.5	2,195	18,296	2½	0	2,555
3.00 "	6,000	584	246.25	123.47	80.3	80	26.5	29.20		103	139	328	195	72		61½	98	....		113,391	35	2,170	20,274	....	....	1,986.5	2,105	20,401	3⅝	485	1,710
3.30 "	6,584	589	246.10	123.39	79.8	79.5	26.5	29.23		94	140	....	....	72		....	94	2,713.2		113,426	23	1,426	21,700	62	6.7	1,633.5	1,444	21,845	4	650	1,279
4.00 "	7,173	591	246.20	123.39	79.8	79	26.5	29.25		96	150	340	208	71		61½	102	....		113,449	29	1,798	23,498	....	....	956	1,906	23,751	3⅛	220	2,246
4.30 "	7,764	591	246.20	123.41	79.8	79	26.4	29.27		108	146	....	....	71		....	107	....		113,478	29	1,798	25,296	46	12.6	2,701.5	1,817	25,568	3	145	1,892
5.00 "	8,355	591	246.10	123.38	79.8	79.5	26.5	29.27		103	147	370	214	71		62	103	....		113,507	30	1,860	27,156	....	....	1,017.5	1,878	27,446	3	145	1,878
5.30 "	8,946	582	246.25	123.32	79.8	79	26.5	29.28		102	156	....	....	71		....	102	....		113,537	29	1,798	28,954	51	8.6	2,665.5	1,817	29,263	3	145	1,817
6.00 "	9,528	596	246.10	123.35	79.3	79	26.5	29.28		100	155	398	228	69		61	100	....		113,566	31	1,922	30,876	....	....	1,956	1,941	31,204	3⅛	220	1,860
6.30 "	10,124	583	246.15	123.38	79.8	79	26.5	29.30		100	156	....	....	69		....	104	....		113,597	33	2,046	32,922	61	3.6	2,021	2,064	33,268	3¼	290	1,994
7.00 "	10,707	590	245.60	123.41	79.3	79	26.5	29.32		96	156	420	246	69		61½	93	....		113,630	27	1,674	34,596	....	....	1,703	1,693	34,961	3½	425	1,658
7.30 "	11,297	586	246.00	123.41	79.8	79	26.5	29.34		99	164	....	....	69		....	108	....		113,657	36	2,232	36,828	47	16.7	2,177.5	2,256	37,217	3⅜	360	2,321
8.00 "	11,883	588	245.75	123.44	79.3	79	26.5	29.35		98	153	430	258	69		61	98	....		113,693	31	1,922	38,750	....	....	1,625.5	1,941	39,158	4	650	1,651
8.30 "	12,471	579	245.80	123.44	79.3	79	26.5	29.37		96	166	....	....	69		....	101	....		113,724	28	1,736	40,486	55	4.6	2,638.5	1,754	40,912	4	850	1,754
9.00 "	13,050	583	245.75	123.43	79.3	79	26.5	29.37		98	168	436	274	69		61½	100	....		113,752	30	1,860	42,346	....	....	1,690.5	1,878	42,790	3⅞	595	1,933
9.30 "	13,633	576	246.20	123.40	79.8	79	26.5	29.37		100	168	....	....	68		....	104	2,130.5		113,782	27	1,674	44,020	48	9.6	1,929	1,693	44,483	4⅛	710	1,578
10.00 "	14,209	579	245.78	123.45	79.3	79	26.5	29.38		100	168	440	278	68		61	101	....		113,809	26	1,612	45,632	....	....	1,763.5	1,630	46,113	3⅞	595	1,745
10.30 "	14,788	580	246.10	123.41	79.8	79.5	26.5	29.39		104	173	....	....	68		....	108	....		113,835	27	1,674	47,306	41	12.6	1,511.5	1,693	47,806	3⅝	485	1,863
11.00 "	15,368	588	246.40	123.39	79.8	79	26.5	29.40		105	174	440	280	71		61	105	....		113,862	30	1,860	49,166	....	....	1,909.5	1,878	49,684	3¼	290	2,073
11.30 "	15,956	580	246.10	123.40	79.8	79	26.75	29.43		104	173	....	....	72		....	104	....		113,892	32	1,984	51,150	49	13.6	2,097.5	2,003	51,687	3¼	290	2,003
12.00 "	16,536	588	245.60	123.48	78.8	78	26.5	29.42		99	167	446	288	72½		61	102	....		113,924	31	1,922	53,072	....	....	1,686.5	1,940	53,627	3¾	540	1,690
Sept. 27. 0.30 a.m.	17,124	589	246.60	123.40	80.3	79	26.5	29.42		96	172	....	....	72		....	98	....		113,955	26	1,612	54,684	59	—1.4	2,017.5	1,631	55,258	4⅛	710	1,461
1.00 "	17,713	598	246.60	123.38	80.3	79	26.5	29.43		98	179	448	298	72		61	98	....		113,981	26	1,612	56,296	....	....	871.5	1,631	56,889	3¾	540	1,601
1.30 "	18,311	587	246.25	123.41	79.8	79	26.5	29.44		104	179	....	....	72		....	107	....		114,007	29	1,798	58,094	41	14.6	2,623	1,816	58,705	3¼	290	2,066
2.00 "	18,898	589	246.25	123.41	79.8	79	26.5	29.44		104	180	450	308	73		61	102	....		114,036	30	1,860	59,954	....	....	1,948	1,878	60,583	3⅛	220	1,948
2.30 "	19,487	586	246.10	123.44	79.8	79	26.75	....		102	181	....	....	....		....	104	....		114,066	31	1,922	61,876	50	11.6	1,967	1,941	62,524	3⅜	360	1,801
3.00 "	20,073	586	246.50	123.40	79.8	79	26.75	29.45		99	174	450	308	73		61	101	....		114,097	31	1,922	63,798	....	....	1,820	1,941	64,465	3⅝	485	1,816
3.30 "	20,659	573	245.90	123.45	79.8	79	26.75	....		98	170	....	....	....		....	101	2,274.5		114,128	25	1,550	65,348	53	3.6	1,721.5	1,568	66,033	3¾	540	1,513
4.00 "	21,232	572	246.25	123.44	80.3	79.5	26.75	29.46		96	172	440	300	72½		61	106	....		114,153	30	1,860	67,208	....	....	1,952	1,878	67,911	3¼	290	2,125
4.30 "	21,804	591	245.75	123.49	79.8	79	26.75	....		104	172	....	....	....		....	106	....		114,183	31	1,922	69,130	48	13.6	1,843	1,941	69,852	3½	425	1,806
5.00 "	22,395	591	246.20	123.42	79.8	79.5	26.5	29.48		100	162	430	294	72		61	102	....		114,214	30	1,860	70,990	....	....	1,987	1,878	71,730	3⅝	485	1,818
5.30 "	22,986	588	246.00	123.39	80.3	79	26.5	....		99	167	....	....	....		....	100	....		114,244	32	1,984	72,974	55	7.6	1,655.5	2,003	73,733	3⅞	595	1,593
6.00 "	23,574	588	246.10	123.41	79.8	79	26.75	29.52		98	166	438	300	72		61	100	....		114,276	26	1,612	74,586	....	....	913.5	1,631	75,364	4⅛	710	1,516
6.30 "	24,162	588	246.20	123.36	80.3	79.5	26.5	....		99	169	....	....	....		....	102	....		114,302	28	1,736	76,322	49	6.6	2,504.5	1,755	77,119	3¾	540	1,925
7.00 "	24,750	590	246.26	123.35	79.8	79	26.5	29.50		102	166	438	294	68		61	104	....		114,330	29	1,798	78,120	....	....	957.5	1,817	78,936	3¾	540	1,817
7.30 "	25,340	582	246.00	123.33	80.3	79.5	26.6	....		102	169	....	....	....		....	105	....		114,359	30	1,860	79,980	47	12.6	2,718.5	1,878	80,814	3⅝	485	1,933
8.00 "	25,922	580	246.26	123.28	79.8	79.5	26.76	29.52		104	168	428	290	69		61	102	....		114,389	30	1,860	81,840	....	....	1,618	1,878	82,692	3¾	540	1,823
8.30 "	26,502	586	246.15	123.28	79.8	79	26.5	....		99	164	....	....	....		....	100	....		114,419	29	1,798	83,638	51	7.6	2,834	1,755	84,447	3¾	540	1,755
9.00 "	27,088	597	246.00	123.27	79.3	79	26.5	29.53		100	166	424	290	71½		61	102	....		114,448	32	1,984	85,622	....	....	1,069	2,003	86,450	3⅝	465	2,058
9.30 "	27,685	409	246.60	123.21	79.8	79	26.5	....		102	171	....	....	....		....	104	2,148.0		114,480	32	1,984	87,606	55	9.6	2,230.5	2,003	88,453	5⅞	1,420	1,778
9.50 "	28,094	222	246.50	123.26	79.8	77.5	26.5	....		....	....	....	....	....		....	....	....		....	....	....	....	....	....	525.5	....	....	....	....	....
10.01 "	28,316	....	....	....	....	....	....	....		98	163	....	....	....		....	98	....		114,512	....	....	....	....	....	....	....	....	4⅛	710	....
....	....	28,316	246.14	123.38	79.9	79.3	26.53	29.35		100.1	183.2	399.8	256.5	70.3	56	61.2	102.1	9,266.2		....	1,413	87,606	....	1,200	216.7	88,453	88,453	....	....	....	88,453

Record of Tests of Two Boilers.— Concluded.

		Boiler No. 2.	Boiler No. 1.
	Commercial Horse-power.		
43	On the basis of 30 lbs. of water per hour evaporated from temperature of 100° F. into steam of 70 lbs. gauge pressure (= 34½ lbs. from and at 212°)		
	Including feed-water heater	119.7 h.p.	120.1 h.p.
	Excluding " " "	114.5 "	113.2 "

NOTE. — During a trial on Aug. 22, 23, Boiler No. 1 evaporated 10 lbs. of water per pound of coal, or an equivalent evaporation of 11.57 lbs. from, and at 212°. The lower evaporation obtained in the trials recorded above are believed to be largely due to the inferior quality of coal used.

The logs of the tests are shown in the table.

BOSTON, Aug. 30, 1888.

MR. WILLIAM JACKSON, *City Engineer, Boston:* —

DEAR SIR, — I beg to report as follows concerning my calorimeter test of the quality of the steam used by the Holly pumping-engine at the Chestnut-Hill Station of the Boston Water Works, during the duty trial of the same, made at your request on the 9th and 10th instant.

The calorimeter used for the test was one of my continuous superheating calorimeters, a description of which is given in the "Transactions of the American Society of Mechanical Engineers," Vol. VII., page 178, and Vol. VIII., page 235, and it was attached to the main 10-in. steam pipe at a point about midway between the boiler and the pumping-engine. The sample of steam tested was drawn through a ½-inch perforated pipe which extended in a horizontal direction into the inside of the main, and diametrically across it.

The tests were in two series, one being made in the early part of the trial and one in the last part.

The steam used by the calorimeter was condensed in a surface condenser, and its weight determined. The whole quantity during the trial amounted to 1,369.5 pounds.

The accompanying record presents the full set of observations, taken after the apparatus had become heated to its normal state, corrected for errors of the thermometers; and appended to the record are computations giving the percentage of moisture obtained from the average readings of the trial.

The result of the tests shows that the steam contained $\frac{24}{100}$ of one per cent. of moisture.

Respectfully submitted,

GEO. H. BARRUS.

CALORIMETER TEST.

Chestnut-Hill Pumping-Station.

TIME.	PRESSURE.	TEMPERATURE OF STEAM SUPPLIED BY SUPERHEATER.		Temperature of sample. Steam when discharged.	WEIGHT OF STEAM CONDENSED DURING PRECEDING HALF-HOUR.	
		Entering jackets.	Leaving jackets.		From Superheater.	From Sample.
Aug. 9.	*Lbs.*	*Deg.*	*Deg.*	*Deg.*	*Lbs.*	*Lbs.*
11.15 A.M.	80.	401.	372.	342.		
.30	79.6	401.5	372.5	343.	34.25	31.
.45	79.7	401.5	372.5	343.		
12.00	80.1	401.	372.	342.5	35.5	31.5
.15	80.	400.5	372.	342.5		
.30	79.4	402.5	373.5	343.	34.25	31.
.45	80.2	402.5	373.5	343.		
1.00	80.4	402.	373.	343.	35.5	31.5
.15	80.	402.5	373.5	343.		
.30	79.6	401.	372.5	343.	34.5	31.25
.45	79.7	403.	373.5	343.		
2.00	80.1	402.	373.5	343.5	34.25	30.75
.15	79.6	401.	373.	343.		
.30	79.7	403.	373.5	343.5	34.5	30.75
.45	79.1	403.	373.5	343.5		
3.00	80.1	402.5	373.5	343.	34.75	30.75
.15	79.7	402.5	373.5	343.		
.30	79.7	402.5	373.5	343.5	34.75	30.5
.45	79.9	403.5	374.	344.		
4.00	79.6	404.	375.	344.	34.75	30.5
.15	79.2	399.	372.	342.		
.30	79.9	397.	370.	342.	35.	30.5
.45	79.6	398.5	371.	342.		
5.00	79.2	398.5	371.	342.	35.	30.5
.15	79.6	399.	371.	342.		
.30	79.2	397.5	370.	341.5	35.	30.5

CALORIMETER TEST. — *Concluded.*

TIME.	PRESSURE.	TEMPERATURE OF STEAM SUPPLIED BY SUPERHEATER.		Temperature of sample. Steam when discharged.	WEIGHT OF STEAM CONDENSED DURING PRECEDING HALF-HOUR.	
		Entering jackets.	Leaving jackets.		From Superheater	From Sample.
Aug. 9.	*Lbs.*	*Deg.*	*Deg.*	*Deg.*	*Lbs.*	*Lbs.*
5.45	79.2	398.	370.	341.5		
6.00	79.8	397.	370.	342.	34.75	30.75
.15	79.5	397.	370.	342.		
.30	79.8	398.	370.	342.	34.75	30.5
Aug. 10.						
8.15 A.M.	79.	397.	368.	340.		
.30	78.9	396.	368.	340.	35.	32.75
.45	79.6	396.5	369.	340.5		
8.00	79.	296.	368.	340.	34.75	33.
.15	79.2	395.	368.	340.		
.30	79.5	394.	367.5	340.	34.5	33.
Average and Totals . .	79.6	399.9	371.6	342.3	625.75	561.

Calorimeter Tests, Chestnut-Hill Pumping-Station. Computations.

		Degrees.
1	Superheat lost by jacket	28.3
2	Superheat lost by jacket, corrected for 6 degrees of radiation	22.3
3	Superheat lost by jacket, corrected for radiation and for ratio between steam used for superheater and that used for sample	24.7
4	Superheat in sample steam when discharged	18.8
5	Superheat in sample steam when discharged, corrected for 1.5 degrees of radiation from supply-pipe	20.3
6	Superheat expended in evaporating the moisture contained in the sample leaving the main (line 3 minus line 5)	4.4
7	Percentage of moisture (line 6 ÷ 18.7)	per cent. 0.24

WEIR MEASUREMENTS.

The following are extracts from the report on the weir measurements by Mr. Desmond FitzGerald, Resident Engineer and Superintendent Western Division Boston Water Works.

Description of Weir.

The 30-inch force main from the pumps delivers into one end of a brick compartment in the gate-house at Fisher Hill. The weir was built into the other end of the compartment in such a manner that the water could discharge freely into the air. The surface of the water in the reservoir was maintained at a fixed height (grade 239.00), something over a foot below the crest of the weir, this being the height at which the correction for leakage from the chamber was made.

The elevation of the weir was 240.164. It was constructed free from end contractions. The sides consisted of a framework faced with boards planed smooth, free from irregularities, parallel and at right angles with the weir. The depth of the water for a considerable distance behind the weir was 20.24 ft., which gave an insignificant velocity of approach, and allowed the water to flow freely and smoothly to the weir. This action was still further aided by sets of screens placed near the delivery end of the force main. The lip was a steel straight edge, nickel plated, 0.0066 in thickness, carefully levelled, before and after each test, by a delicate bubble, made by Buff & Berger. The exact length was determined by a special brass rod fitted with sliding scale and vernier. The mean of a number of measurements made the length of the weir 5.008 ft.

Hook Gauge.

The hook gauge was arranged after the method recommended by Fteley and Stearns in their hydraulic experiments.

A plate was fitted normal to the current on the side of the box, at a distance of 6 ft. above the weir and 0.4 ft. below the crest. From the centre of the plate a rubber hose led to the gauge-chamber, which was conveniently placed in another compartment of the gate-house adjoining the weir chamber, and separated therefrom by a water-tight dam.

The 0 of the gauge was placed level with the lip of the weir by means of the same apparatus used by Fteley and Stearns, and which gives a very delicate method of adjusting the levels. It is fully described and illustrated in the proceedings of the American Society of Civil Engineers.

Observations.

The heights of the water flowing over the weir were taken every five minutes throughout the duty trials by two observers, who alternated in descending into the chamber. Each observer checked the previous reading before taking a new observation. By this method errors were reduced to a minimum.

Formula.

In the general formula for flow over a weir with end contractions suppressed, the coefficient 3.35 was adopted from the Fteley and Stearns experiments on a weir of same length and about the same flow. The correction for the velocity of approach was computed after the method recommended by Hunking and Hart, and was found to be 1.00043 for August 9–10, and 1.00044 for September 26–27. For five minutes, or three hundred seconds, we have

$$\Sigma Q_g = 7.48 \times 300 \times 3.35 \times 5.008 \times 1.0004^3 \times \left(\Sigma H_m^{\frac{3}{2}}\right)$$

The following method was pursued in working out the details. The heights at the beginnings and ends of the 5-mt. periods were added and their mean taken for a new height $= H_m$.

The $\frac{3}{2}$ power of this height was then found and placed in a column. The total sum of the number in this column gave $\left(\Sigma H_m^{\frac{3}{2}}\right)$ completing the numerical values in the above formula.

This process is somewhat laborious, but is believed to give results that will be found trustworthy.

The Tests.

The following is a brief summary of the test made on Aug. 9–10, 1888. Water arrived at weir at 10h. 21m., August 9, and ceased running at 10h. 13m., August 10.

Treating first the even periods of 5 mts., we have $\Sigma H_m^{\frac{3}{2}} = 213.7545$

$\therefore \Sigma Q_g = 7.48 \times 300 \times 3.35 \times 5.008 \times 1.00043 \times 213.7545$

=	8,050,700 gals.
Flow from 10h. 21m. to 10h. 25m., August 9 . .	21,558 "
" " 10h. 10m. to 10h. 13m., " 10 . .	16,964 "
Rise in weir box before normal flow	1,661 "
Leakage (measured), main, gates, weir, etc. . .	21,842 "
Total	8,112,725 gals.

The following extract from the log for one hour is sufficient to show the details, Aug. 9, 1888: —

Time.	H.	H_m.	H_m^3.	$H_m^{\frac{3}{2}}$.	$\Sigma H_m^{\frac{3}{2}}$.
12–00	0.833	0.8360	0.5843	0.7644	13.9576
05	0.824	0.8285	0.5687	0.7541	
10	0.837	0.8305	0.5728	0.7568	
15	0.834	0.8355	0.5837	0.7637	
20	0.835	0.8345	0.5811	0.7623	
25	0.860	0.8475	0.6087	0.7802	
30	0.858	0.8590	0.6338	0.7961	
35	0.848	0.8530	0.6207	0.7878	
40	0.823	0.8355	0.5832	0.7637	
45	0.852	0.8375	0.5874	0.7664	
50	0.828	0.8400	0.5927	0.7699	
55	0.801	0.8145	0.5403	0.7351	
13–00	0.807	0.8040	0.5197	0.7209	9.2005

The test of Sept. 26–27, 1888, was treated in a similar manner. It will be unnecessary to repeat the methods pursued. The following is a brief summary.

Water arrived at wier at 9h. 49½m., September 26, and stopped 9h. 50m., September 27, giving a total flow of	8,353,497 gals.
Add leakage and rise in wier box	23,503 "
Total	8,377,000 gals.

Iron Pier at Marine Park.

Work on this pier was resumed on Feb. 20, 1888. The wooden-pile structure connecting the iron pier and the temporary wooden pier was completed on October 13, and the iron pier and its railings so far completed as to be opened to the public on Dec. 2, 1888.

A contract was made on Oct. 20, 1888, with Messrs. Shailer & Schniglau, of Chicago, Ill., for furnishing four additional spans of iron pier, and work under this contract will be begun early in the coming spring.

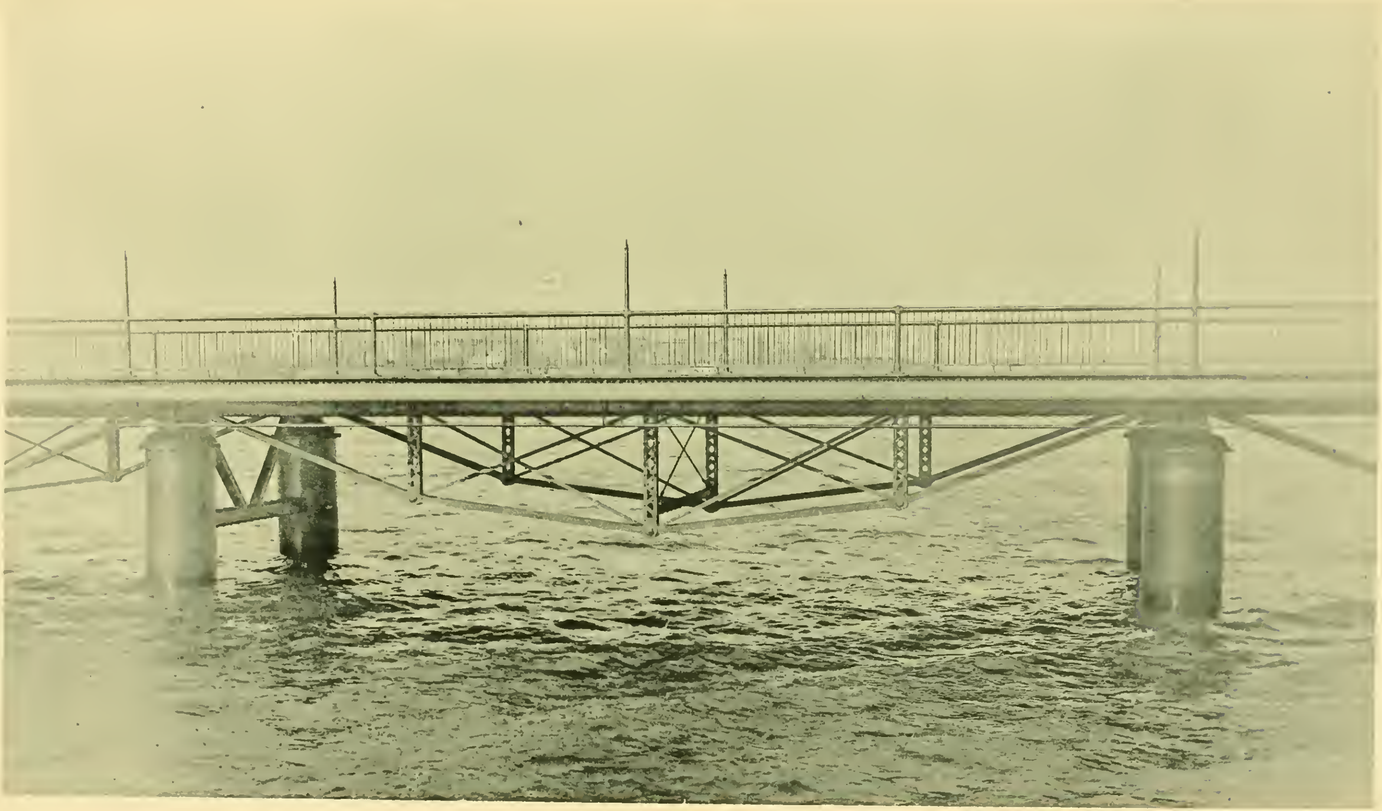
The portion of pier completed in December last comprised seventeen spans, or a total length of 1,049.75 ft.

The iron pier commences at the outer end of the temporary wooden pier built in 1886, a point about 1,250 ft. from the shore at mean high water, and is built with its centre line on the arc of a circle of 2,500 ft. radius, the pier curving toward the north. It is to be used exclusively as a promenade. The pier is 35 ft. 2 in. between centre lines of railings, and its floor is 24 ft. 6 in. above Grade O, City Base, which is approximately the level of mean low water. At mean low tide there is from 3 ft. to 6 ft. 6 in. depth of water on the line of the pier, with an additional depth of mud or soft material of from 24 ft. to 29 ft. The greatest distance from Grade O to hard bottom is 33 ft.

The so-called hard bottom is a very tough and compact clay, which is known to extend to a great depth in that portion of the harbor where the pier is located. The pier is made of iron deck-spans, supported on cast-iron cylinders or pier-piles, its general construction being shown in the accompanying view.

The pier piles are cast-iron cylinders, 4 ft. 6 in. outside diameter, and 1⅛ in. thick. They are made in lengths of about 8 ft., excepting the special top sections and those necessary to make up a required length of pile, and are provided with internal flanges. These flanges were faced and the joints between them filled with red lead before being bolted together.

The pier piles were placed 11 ft. each side of the centre line of the pier, and on lines radial to the same; the chord



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IRON PIER AT MARINE PARK,

VIEW OF ONE 60 FT. SPAN.

distance between these lines, at centre of pier, being 61 ft. 9 in.

The cylinders were sunk 8 ft. into the clay bottom, the soft material being removed by a dredging bucket, and the clay being dug and cut out by hand tools. The maximum length of pier piles from cap joint to bottom is 61 ft.

The mud and soft material is of such a nature as to prevent water from entering the cylinders while being sunk.

After a cylinder had reached the required depth, it was held in position vertically, and the clay dug out below it, forming an excavation, or pocket, about 7 ft. in diameter, and 2 ft. 6 in. to 3 ft. deep. This pocket, and about 8 ft. in length of the cylinder, was immediately filled with concrete. The work of digging and filling this pocket was done as quickly as possible, and the contractor was not allowed to begin it unless it could be carried forward without interruption. After the concrete in the pocket had become partially set, the work of filling the entire cylinder with concrete was proceeded with, the cross bracing attached, and the floor beams over cylinders and the truss-seat castings adjusted to proper position and grade, and bedded in the filling.

The concrete used in the work was made of Portland cement, sand, and broken stone, pebbles, or coarse gravel, in the following proportion: —

From bottom of excavation to Grade O, cement, 1 part; sand, 3 parts; stone, 7 parts.

From Grade O to Grade 15 ft., cement, 1 part; sand, 3 parts; stone, 5 parts.

From Grade 15 ft. to Grade 19 ft., cement, 1 part; sand, 2 parts; coarse gravel, 5 parts.

Mortar made of 1 part cement and 2 parts sand was used for the rest of the cylinder, and the filling of the cap and truss-seat castings was completed with tar roofing compound, to make the work water-tight.

The superstructure of the pier consists of wrought-iron deck-spans. Each span has two pin-connected trusses, of the inverted bow-string type, each 60 ft. long between centres of end pins, and 7 ft. 6 in. deep at middle. Floor beams are built iron girders, those over pier piles being double webbed and connected to wrought-iron posts built into the cylinders.

Floor joists are hard pine, and the floor planking is one course of 2-in. clear hard pine, planed on one side to an even thickness and jointed, laid diagonally.

The railings are of wrought-iron, with the exception of the posts over the floor beams, which are cast-iron. Every alternate post extends above the railing, and is fitted with a gas lamp.

The Builders Iron Foundry, of Providence, R.I., were the contractors for the work, and the amount paid them for the seventeen spans of pier complete was $134,664.33.

NORTH PAVING WHARF.

The work of rebuilding this wharf, which was under contract at the beginning of the year, was completed in April. It is a substantial wharf, built with oak piles, hard-pine timber, and kyanized spruce covering. The wharf and platform adjoining it covers an area of 9,100 square feet.

PROPOSED BRIDGE TO EAST BOSTON.

The City Council, by an order approved by the Mayor Dec. 24, 1888, directed the City Engineer to prepare plans and estimates for the construction of a bridge to connect East Boston with the city proper.

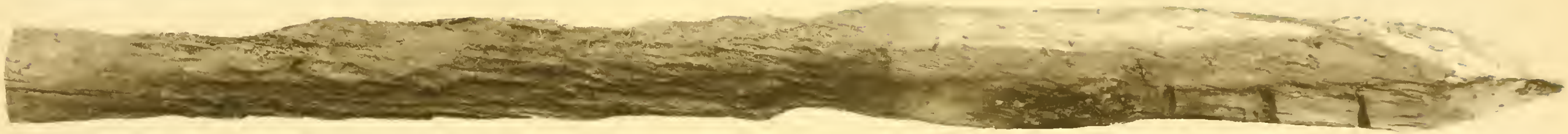
In past years approximate estimates had been made for this purpose from the data available, and it was presumed that the purpose of the Council's order was to obtain more definite plans and estimates. To do this it is necessary to first obtain by proper surveys and borings definite facts to work from, and the City Council will consequently be asked to appropriate the sum of $2,500, which will be required to obtain this information.

QUINCY-STREET BRIDGE.

The railroad bridge over Quincy street, built by the New York & New England Railroad, at the joint expense of the road and city, and to the approval of the City Engineer, has been finished. It is a plate girder bridge of 38 feet span, carried on stone abutments laid solid in cement mortar on a spruce-pile foundation. The cost to the city was $5,421.17.

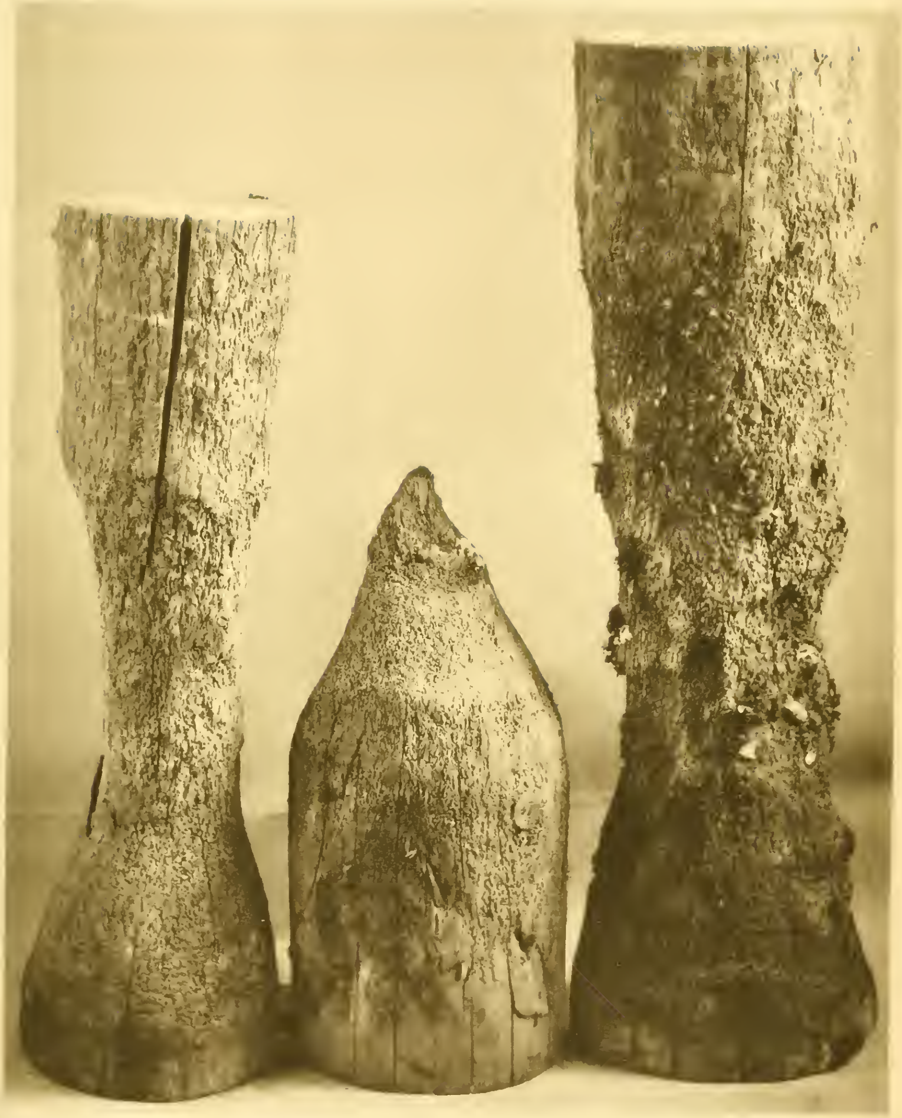
SEA-WALL ON ROXBURY CANAL.

The city's wharf, adjoining the south yard of the Water Department, has been added to the pipe-yard, and the wall on Roxbury Canal has been rebuilt in a similar manner to the wall built last year on the old part of the wharf. The masonry plans and specifications were prepared by this department, and the work was done by Charles E. Edwards. It was finished in August and cost $5,965.90.



HELIOTYPE PRINTING CO. BOSTON, MASS.

OAK PILE 23 FT. LONG, 16 INS. DIAMETER, REDUCED IN SIZE BY THE LIMNORIA TEREBRANS.



HELIOTYPE PRINTING CO.

BOSTON MASS.

Spruce Piles Destroyed by the Limnoria Terebrans.

WATER-PIPE BRIDGE.

The Water-Pipe Bridge, between Charlestown and Chelsea, the rebuilding of which was begun last year, was completed in April. Total cost of bridge and boxing, $14,928.04. The structure was described in the last annual report.

Other work of a miscellaneous character was principally as follows : —

Plans and Specifications.

For Superstructure of Wood Island Park Bridge.
" Extension of Iron Pier, Marine Park.
" Water-pipe under railroad tracks on Travers street.
" Fence at Charles River Embankment.
" " " Marine Park Pier.
" " " Gymnastic Grounds, Charles River Embankment.
" Connecting Iron and Wooden Piers, Marine Park.
" Water Tank, Breed's Island.
" Athletic Apparatus, Charles River Embankment.
" Coal House Roof, Mystic Pumping-Station.
" Rebuilding the City's Wharf, No. 600 Albany street.

Estimates.

For Foot Bridge at Camden street.
" " " " Berwick Park.
" Bridges over N.Y. & N.E. R.R., South Boston Flats.
" Abutments and Bridge on Leyden street.

The usual large amount of work of a general character has been done during the year. Under this head may be classed record-plans, maps for Water-Works and Park Department, copying, tracing, and blue-printing plans.

SPECIAL EXAMINATION OF PILING.

During the year an examination of the piling under portions of eleven bridges was made by a diver, under the direction of Assistant Engineer Henry Manley, to find the damage done by the *Limnoria*, or pile-worm, with substantially negative results; in only two cases was serious damage found, and these were both previously known. In fact, cases of serious damage can usually be discovered by an examination at low water of spring tides. The two cases referred to were the draw pier of Broadway bridge and the draw foundation of Chelsea-street bridge: Winthrop bridge is badly damaged by the *Limnoria*, and was repaired by driving new piles, in 1887. In this case the bridge is left nearly dry at extreme low water, and its condition can be seen. (For particulars see notes on these bridges.)

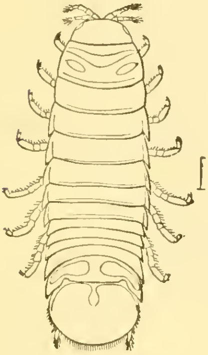

No. 531

Figure 2.—*Limnoria lignorum;* dorsal view, enlarged ten diameters.

The diver also examined the wharves at Deer, Rainsford, and Gallop's islands. Gallop's-island wharf is but slightly affected. Rainsford and Deer island wharves are both seriously damaged, and should be examined at intervals of one or, at the most, of two years, and repairs made when found necessary. No repairs on account of damage from this source are required at present; both these wharves have been once rebuilt because of the destruction of their piling by the *Limnoria.*

There are three marine animals on the Atlantic coast of the United States that do serious damage to submerged woodwork. Only one of them, the *Limnoria terebrans*, as it is called in most works on the preservation of timber, or *Limnoria lignorum*, as it is called by naturalists, is found in this harbor in considerable numbers. It is not found in brackish waters, and water contaminated with sewage is not favorable to it. It is most met with in the clear waters of the lower harbor, being found in abundance at Deer island and Rainsford island, although for some unknown reason but few are found at Gallop's island.

Spruce and soft woods are rapidly eaten; while oak piles endure much longer. The wharf at Deer island (of oak), which was rebuilt in 1879, because of their ravages, had been built twenty-four years.

The following account is taken from "The Fisheries and

Fishery Industries of the United States," by Geo. Brown Goode, 1884, a publication of the United States Fish Commission : —

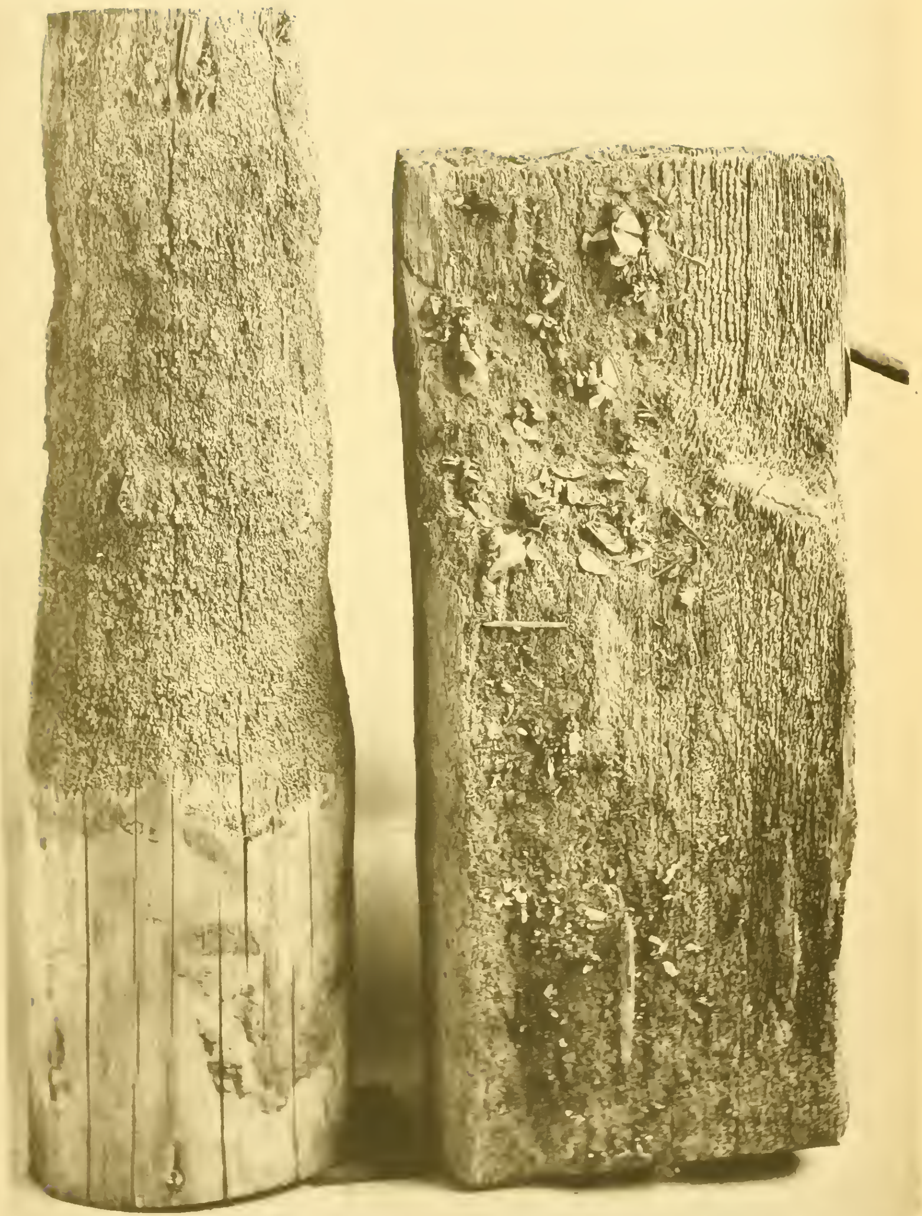
THE GRIBBLE, OR BORING LIMNORIA — LIMNORIA LIGNORUM, WHITE.

"The little crustacean pest, which measures less than one-fifth of an inch in length, is a very common inhabitant of our Atlantic coast from the Gulf of St. Lawrence to Florida, and also occurs abundantly on the coast of Great Britain and of other parts of Europe. In spite of its small size, it is very destructive to all kinds of sub-marine wood-work, which it rapidly eats away. Its body, which is sub-cylindrical in shape, consists of fourteen segments, the anterior one being the head ; the two ends are rounded and the sides are nearly straight and parallel to one another. The first seven segments, not including the head, bear each a pair of short legs. It makes its burrows by means of stout mandibles or jaws. In color it is grayish, the upper surface of the body being covered with minute hairs, to which more or less dirt usually adheres.

"The Gribble generally lives above and just below low-water mark, but has been found at times, though very rarely, as low down as seven to ten fathoms. It gnaws burrows into all sorts of sunken or floating wood near the shore, and lumber or drift-wood left for some time on muddy shores is pretty certain to be attacked by it. The burrows are made to a depth of about half an inch, and when they become numerous enough to reduce the superficial layer of wood to a mere honey-comb, it scales off, leaving a fresh surface, which is at once attacked. Much damage is done by this little creature to the piles of wharves and other sub-marine wood-work all along our Atlantic coast, and numerous methods of stopping its ravages have been devised. It has been observed attacking the gutta percha of submarine telegraph cables. Professor Verrill describes its habits and the damage it has done on the American coast, as follows : 'It has the habit of eating burrows for itself into solid wood to the depth of about half an inch. These burrows are nearly round, and of all sizes up to about a sixteenth of an inch in diameter, and they go into the wood at all angles, and are usually more or less crooked. They are often so numerous as to reduce the wood to mere series of thin partitions between the holes. In this state the wood rapidly decays, or is washed away by the waves, and every new surface exposed is immediately attacked, so that layer after layer is rapidly removed, and the timber thus wastes away and is entirely destroyed in a few years. It destroys soft woods more rapidly than hard ones, but all kinds are attacked except teak. It works chiefly in the softer parts of the wood, between the hard, annual layers, and avoids the knots and lines of hard fibre connected with them, as well as rusted portions around nails that have been driven in, and consequently, as the timber wastes away under its attacks, these harder portions stand out in bold relief.

"'Where abundant it will destroy soft timber at the rate of half an inch or more every year, thus diminishing the effective diameter of piles about an inch annually. Generally, however, the amount is probably not more than half this; but even at that rate the largest timbers will soon be destroyed, especially when, as often happens, the *Teredos* are aiding in this work of destruction. It lives in a pretty narrow zone, extending a short distance above and below low-water mark. It occurs all along our shores, from Long Island sound to Nova Scotia. In the Bay of Fundy it often does great damage to the timbers and other wood-work used in constructing the brush fish-weirs, as well as to the wharves, etc. At Wood's Holl it was found to be very destructive to the piles of the wharves. The piles of the new government wharves have been protected by broad bands of tin-plate covering the zone which it chiefly affects. North of Cape Cod, where the tides are much greater, this zone is broader, and this remedy is not so easily applied. It does great damage also to ship timber floating in the docks, and greater losses are sometimes caused in this way. Complaint of such ravages in the navy-yard at Portsmouth, N.H., have been made, and they also occur at the Charlestown navy-yard and in the piles of the wharves at Boston. Probably the wharves and other submerged wood-work in all our seaports, from New York northward, are more or less injured by this creature, and, if it could be accurately estimated, the damage would be found surprisingly great.

"'Unlike the *Teredo*, this creature is a vegetarian, and eats the wood which it excavates, so that its boring operations provide it with both food and shelter. The burrows are made by means of its stout mandibles, or jaws. It is capable of swimming quite rapidly, and can leap backward suddenly by means of its tail. It can creep both forward and backward. Its legs are short and better adapted for moving up and down in its burrow than elsewhere, and its body is rounded, with parallel sides, and well adapted to its mode of life. When disturbed it will roll itself into a ball. The

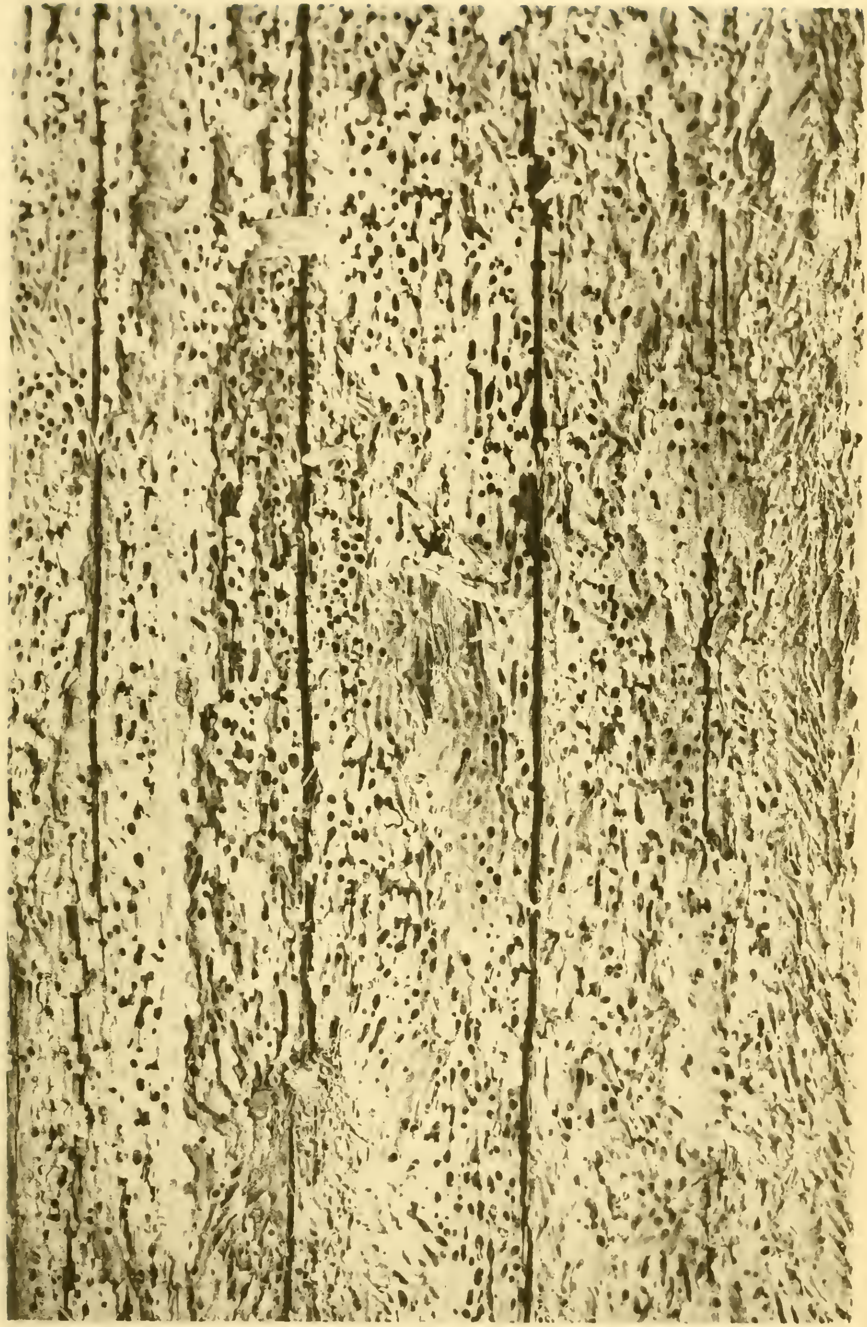


HELIOTYPE PRINTING CO. BOSTON MASS.

NO. 1. NO. 2.

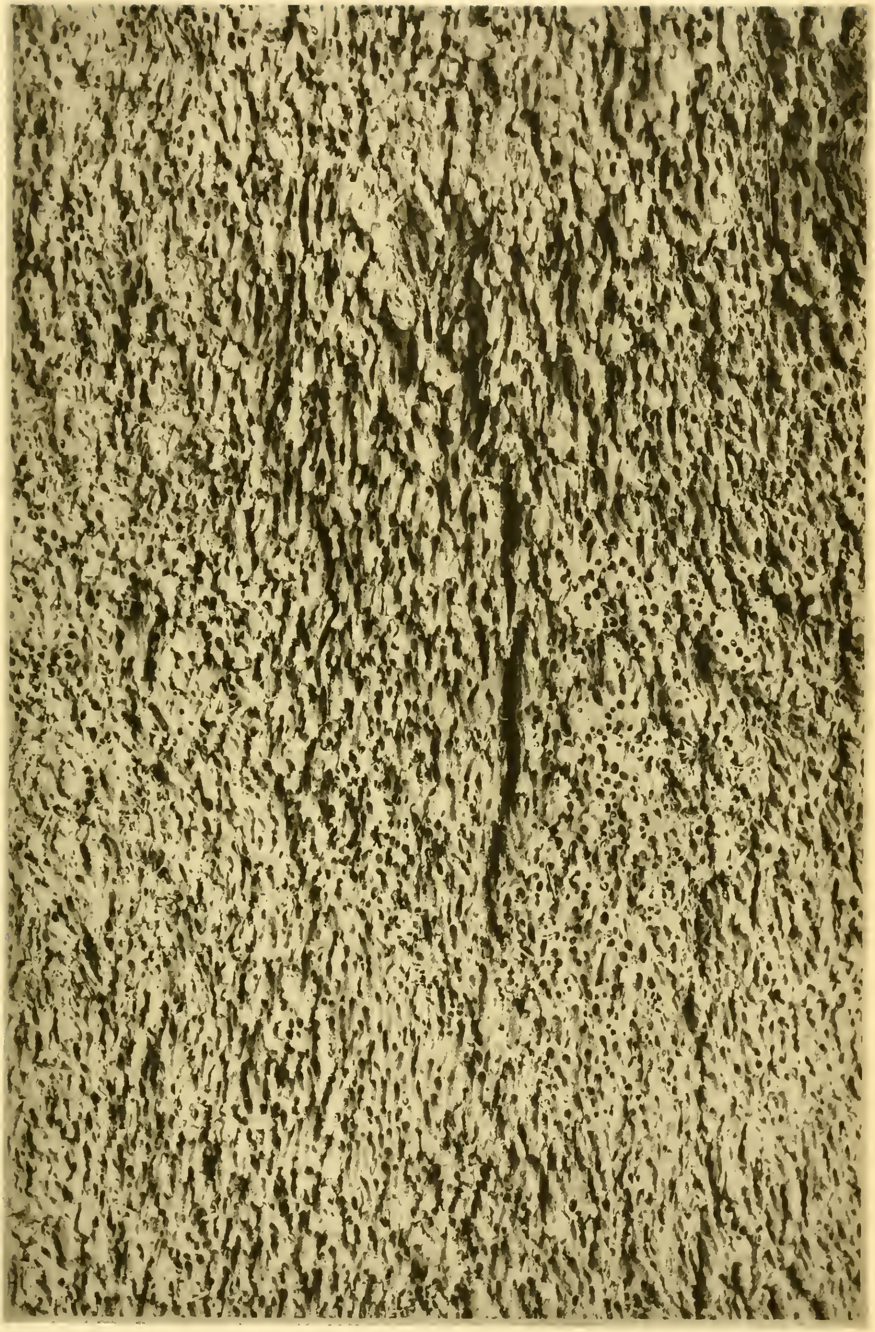
No. 1.—Spruce Pile Attacked by the Limnoria Terebrans. The Lower Part Shows the Pile Uninjured, Where it was Under the Mud.

No. 2.—Hard Pine Timber Attacked by the Limnoria.



HELIOTYPE PRINT'G CO. BOSTON, MASS.

SURFACE OF SPRUCE PILE ATTACKED BY THE LIMNORIA TEREBRANS. FULL SIZE.



HELIOTYPE PRINTING CO. BOSTON, MASS

Surface of Hard Pine Attacked by the Limnoria Terebrans. Full Size.

female carries seven to nine eggs or young in the incubatory pouch at one time.

"'The destructive habits of this species were first brought prominently to notice in 1811, by the celebrated Robert Stephenson, who found it rapidly destroying the wood-work at the Bell Rock Light-house, erected by him on the coast of Scotland. Since that time it has been investigated, and its ravages have been described by numerous European writers. It is very destructive on the coast of Great Britain, where it is known as the "Gribble."

"'The remedies used to check its ravages are chiefly copper or other metallic sheathing; driving broad-headed iron nails, close together, into the part of the piles subject to their attacks; and applying coal-tar, creosote, or verdigris-paint once a year or oftener.'"

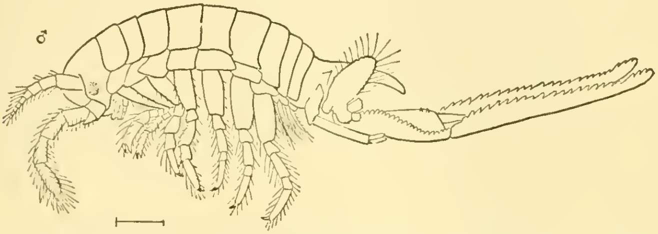


Figure 1.—*Chelura terebrans;* male; lateral view, enlarged about twelve diameters.

The two remaining animals referred to are the *Teredo navalis*, or ship-worm, and the *Chelura terebrans*. The *Teredo* is found in warm climates in nearly all parts of the world. In appearance it is a large soft worm, and may grow to the length of eighteen inches and to a diameter of three-eighths of an inch; it burrows in the interior of the timber, and when it is numerous the timber is soon reduced to a mere shell. It is abundant on the southern coast of Massachusetts, but is not found north of Cape Cod.

Of the *Chelura*, the authority already quoted says: —

"This very destructive little crustacean, which is of common occurrence on the European coast, from southern Norway to the Adriatic Sea, has so far been noticed on the Atlantic coast of the United States at only two places, Wood's Holl and Provincetown, Mass.

"At both of these localities it was found associated with the 'gribble' (*Limnoria lignorum*), in the submerged piles of old wharves. It is more than possible, however, that it is a common inhabitant of our coast, doing a certain amount of the damage hitherto ascribed to other boring animals. Without a careful examination, it is quite easy for an unskilled eye to confound *Chelura* with *Limnoria*, although they belong to very distinct divisions of the *Crustacea*."

Specimens of timber secured by the diver from two localities infested by the *Limnoria* were submitted to Prof. S. I. Smith, of New Haven (who first identified the *Chelura* in this country), and to Professor Hyatt, of the Boston Society of Natural History, and were carefully examined by them, but no specimens of the *Chelura* were found. The sample of spruce timber examined was taken from Broadway bridge at a depth of about fourteen feet below low water, and the oak timber came from Chelsea-street bridge in East Boston at a depth of about twenty feet at low water. The *Limnoria* was abundant in each case.

The cuts of the *Limnoria* and *Chelura* are from drawings by Professor Smith, and were furnished by the kindness of the Secretary of the Smithsonian Institution of Washington.

The heliotypes, showing the manner in which the *Limnoria* does its work, were made from piles taken up by the Boston Tow Boat Company from its wharf in East Boston.

The heliotype of the oak pile twenty-six feet long, shows that the part which was under the mud is uninjured, while the originally lager part, which was above the mud and exposed to the action of the *Limnoria*, has been greatly reduced in size.

B. — WATER WORKS.

SOURCES OF SUPPLY.

The rainfall during the first seven months of the year was a little below the average, but since August 1 it has been unusually heavy, the total rainfall for the year at Lake Cochituate being the largest recorded since 1869.

The rainfall and quantities collected on the several watersheds are as follows: —

	Sudbury.	Cochituate.	Mystic.
Rainfall, inches,	57.465	56.93	56.745
" collected inches,	35.749	30.97	31.12
Daily average yield, gallons,	127,642,900	27,751,400	25,001,600

The quality of the water from the Sudbury and Cochituate supplies has been good, and that from the Mystic has caused less complaint than usual.

The fluctuations in the amount of storage in the different lakes and reservoirs are shown graphically by an appended diagram. The condition of the different reservoirs during the year is given below: —

CONSUMPTION.

The daily average consumption from the combined works has been as follows: —

	Cochituate Works.	Mystic Works.	Totals.
January	40,485,700	11,107,100	51,592,800
February	43,105,000	11,620,900	54,725,900
March	36,463,400	9,242,000	45,705,400
April	31,473,800	7,276,700	38,750,500
May	30,802,000	6,932,300	37,734,300
June	31,026,100	7,615,200	38,641,300
July	32,014,400	8,267,500	40,281,900
August	32,432,700	7,859,100	40,291,800
September	31,836,500	7,266,300	39,102,800
October	29,110,800	7,096,400	36,207,200
November	28,590,900	6,990,800	35,581,700
December	32,686,200	7,918,600	40,604,800
Averages	33,310,700	8,258,400	41,569,100

The daily average consumption per head of population has been as follows : —

Sudbury and Cochituate supply	88	gallons.
Mystic supply	76.5	"
Total supply	85.4	"

The above figures show an increase of 11.6 per cent. in the consumption from the Sudbury and Cochituate works over that of the year 1887, of 8.2 per cent. from the Mystic works, and of 10.9 per cent. from the combined supplies. The increase of consumption is large, and is mainly due to the long-continued cold weather in the early months of the year, the increase during the latter months not exceeding the rate of increase of the population.

SUDBURY-RIVER RESERVOIRS AND LAKE COCHITUATE.

Reservoir No. 1. — Water was wasting at the dam on January 1, and, with the exception of two days in January, continued to waste until June 8, when the stop planks were placed upon the dam. On June 28 wasting began again, and continued until July 13. The surface of the reservoir continued near high-water mark the balance of the season, waste beginning again on August 23, and continuing until the present time.

Reservoir No. 2. — This reservoir was full until June 24; it then gradually fell until August 4, when the surface of the water had fallen to grade 160.53, or 6.6 feet below the top of the flash-boards, which was the lowest point reached during the year. Water has been flowing over the dam from September 23 to the present time.

Reservoir No. 3. — Water was flowing over the dam from January 1 to January 25, from February 22 to February 23, from March 28 to June 6, from June 26 to July 10, and from August 24 to the present time. The lowest point reached during the year was on March 20, when the surface of the water was at grade 169.41, or 5.83 feet below the crest of the dam.

Reservoir No. 4. — On Jan. 1, 1888, the water in the reservoir stood at grade 207.89, or 7.32 feet below the top of the flash-boards. The reservoir gradually filled during January and February, and the water remained in the vicinity of high-water mark until the 1st of August, when the reservoir was drawn upon to supply the city. On August 21 the water was at grade 211.20, and after that date it began to rise, reaching the top of the stop-planks on September 28. Since that date the reservoir has remained practically full.

Farm Pond. — The surface of this pond has been kept at an average level of 149.11 feet above tide-marsh level.

The conduit through the pond was in use from June 23 to July 10, and from December 15 to December 31. During the balance of the year the water was taken through the pond.

The Framingham Water Company has pumped 61,500,000 gallons from the pond, or a daily average of 168,033 gallons.

Lake Cochituate. — On Jan. 1, 1888, the surface of the lake was at grade 125.63, or 8.73 feet below high water. It began to rise during the latter part of February, until, on March 31, it reached grade 131.20, but soon began to fall.

Excepting August, water was wasted at the outlet of the lake during a part of each month, from March to December, inclusive, so as to allow the work to be done at the Pegan meadows.

On August 20, a contract was made with Auguste Saucier for the removal of 60,000 cubic yards of material on Pegan meadows for the improvement of the shallow flowage, so as to give a depth of 6 feet on the meadows at high water.

The accomplishment of this work was attended with much difficulty, on account of the unusual amount of rainfall, and the contractor is to be complimented for the fidelity with which he has carried out his agreement.

The plans for building a new dam at the outlet of the lake have been revised during the year, and late in the season the work of construction was commenced; but the necessity of wasting large volumes of water, in order to allow the work on the Pegan meadows to be completed, has delayed the work, and, excepting the coffer dam, but little has been done.

Water has been drawn from the different reservoirs on Sudbury river to supply the city, as follows: —

	Reservoir No. 1. Top of flash-boards, 159.29.	Reservoir No. 2. Top of flash-boards, 167.12.	Reservoir No. 3. Crest of dam, 175.24.	Reservoir No. 4. Top of flash-boards, 215.21.	Farm Pond.	Lake Cochituate. Top of flash boards, 134.36.
Jan. 1, 1888	157.79	165.94	175.46	207.89	149.24	125.63
Feb. 1, "	157.59	166.25	174.28	211.67	149.21	125.70
March 1, "	158.05	166.20	173.40	215.21	149.22	128.84
April 1, "	158.52	166.29	175.49	213.80	149.17	131.16
May 1, "	157.87	166.04	175.37	214.64	149.25	130.02
June 1, "	157.97	166.16	175.52	215.17	149.28	130.12
July 1, "	159.40	166.17	175.38	215.14	149.25	128.59
Aug. 1, "	158.58	161.25	173.49	215.09	149.28	126.48
Sept. 1, "	159.34	163.88	175.32	211.92	149.24	126.11
Oct. 1, "	158.08	167.39	175.62	215.20	147.46	128.03
Nov. 1, "	156.62	167.39	175.63	215.18	149.27	127.84
Dec. 1, "	156.68	166.67	175.72	214.79	149.28	129.90
Jan. 1, 1889	158.07	166.24	175.58	214.61	149.25	130.71

Reservoir No. 2, Jan. 1 to 22 inclusive.
June 23 to July 9 inclusive.
July 25 to September 12 inclusive.
September 17 to September 26 inclusive.
September 29 to October 15 inclusive.
October 21.
Reservoir No. 3, January 31 to June 7 inclusive.
November 3 to December 12 inclusive.
Reservoirs Nos. 2 and *3*, January 23 to 30 inclusive.
June 7 to 20 inclusive.
July 10 to 24 inclusive.
Reservoirs Nos. 2 and 3, September 16 to 20 inclusive.
September 22 to November 2 inclusive.
December 13 to December 31 inclusive.
Farm Pond, January 1 to June 23.
July 10 to December 15.

AQUEDUCTS AND DISTRIBUTING RESERVOIRS.

The Sudbury-river aqueduct has been in use during the whole or portions of 362 days, and the Cochituate aqueduct has been in use 358 days. The former has delivered into Chestnut-Hill and Brookline reservoirs 7,224,700,000 gallons, equal to a daily average supply of 19,739,600 gallons, and the latter has delivered 4,968,503,100 gallons, or 13,575,100 gallons per day.

Both aqueducts have been cleaned during the year; the details of this work will be found in the report of the Superintendent of the Western Division.

In the Cochituate aqueduct, from February 22 to June 27, and from September 27 to December 31, a depth of 6 feet of water was run; from June 27 to July 8, a depth of 6 feet 6 inches was run; for the balance of the year the depth of water run in the aqueduct followed the level of the lake.

The Chestnut-Hill, Brookline, Fisher-Hill, Parker-Hill, and East Boston reservoirs are in good condition.

Fisher-Hill reservoir has been in use during the whole year. The grading of the grounds was finished during the early part of the summer, a drain-pipe was laid from the back side of the reservoir lot to connect with the drain in Fisher-Hill avenue, shrubs were planted, the walks and slopes resurfaced, and the slopes and grounds seeded with grass.

The loam surfacing of the slopes slipped in three or four places during the very severe storm of September 26, and another small slip occurred during the storm of November 26. These slips are common to new embankments with a clayey subsoil, but will not probably occur after a strong sod has formed.

Parker-Hill reservoir was shut off from the distribution, and the high-service districts were supplied directly from Fisher-Hill reservoir from Dec. 3, 1887, to July 2, 1888. Since that date a circulation has been kept up in the reservoir by throttling the inlet gate.

West Roxbury has been supplied directly from Fisher Hill during the entire year.

HIGH-SERVICE PUMPING-STATIONS.

The Elmwood-street pumping-station was discontinued on May 8, at 11 P.M., after having been in use since March 1, 1870, and the force of engineers and firemen was transferred to Chestnut Hill. The daily average amount pumped at this station, from January 1 to May 8, was 3,659,400 gallons.

The Brighton pumping-station was closed in January, and the engineer transferred to Chestnut Hill. The pumps have been taken down, and one of them will be transferred to the new station at East Boston to pump the water for the Breed's Island high service.

The Brighton pumping-station was built in 1876 for the temporary supply of the high-service district of Brighton until the Chestnut-Hill pumping-station should be built.

At the East Boston station the daily average amount pumped from January 1 to October 30 was 353,200 gallons; since the last date, with the exception of one day in December, no water has been pumped, as, on account of the increased supply furnished by the new 24-inch main, the reservoir can be filled from the low-service mains at night. During extreme cold weather pumping will have to be resorted to.

At the West Roxbury pumping-station the daily average amount pumped was 40,560 gallons. The daily amount of water used varied from an average of 20,800 gallons in April to 74,800 gallons in January, but nearly one-half of the apparent consumption during the winter months was due to the opening of a connection between the West Roxbury high service and the general high service to prevent the freezing of the water in the pipe over the Park-street bridge.

The tank on Bellevue Hill has been enclosed by an observatory tower, which it is expected will prevent any trouble from ice in the tank.

NEW HIGH-SERVICE WORKS.

Work upon the pumping-machinery and boilers was so far advanced January 21 that fires were started under one of the boilers, and engine No. 1 was run for a short time.

On February 1, engine No. 2 was started, and they were run irregularly nearly every day until May 9, when they were put into regular service, the pumps at Elmwood street being abandoned. The pumps are completed, excepting some minor details and painting.

A duty trial was made of engine No. 1, together with boiler No. 2, on August 9 and 10, and trials were made of engine No. 2, with boiler No. 1, on August 22 and 23, and on September 26 and 27. See details on pages 22–36.

Amount of water pumped at Elm-street and Chestnut-Hill pumping-stations in 1888.

	Elmwood street.	Chestnut Hill.	Total.
January	141,970,300	2,271,500	144,241,800
February	115,072,000	31,011,875	146,083,875
March	102,284,500	35,349,850	137,634,350
April	92,287,000	31,643,175	123,930,175
May	20,444,500	107,409,500	127,854,000
June	. . . .	144,288,925	144,288,925
July	. . . .	171,114,750	171,114,750
August	. . . .	170,841,875	170,841,875
September	. . . .	160,001,215	160,001,215
October	. . . .	157,559,500	157,559,500
November	. . . .	151,792,250	151,792,250
December	. . . .	170,032,100	170,032,100
Daily average amount pumped	. . . .	. . . .	4,932,700 gallons.

In June several districts were changed from low service to high service. In the city proper, 3.5 miles of streets were so changed; in Roxbury, 3.9 miles; in Dorchester, 2.2 miles; and in West Roxbury, 0.6 miles.

The amount of water used by the high service increased from 3,691,000 gallons per day in 1887 to 4,952,700 gallons in 1888; the increase during the last half of the year, after the territory supplied was enlarged, being 1,597,600 gallons per day, or 42.8 per cent. over the consumption for the corresponding months in 1887.

DESCRIPTION OF CHESTNUT-HILL PUMPING-STATION.

The buildings consist of an engine-room 84 feet 10 inches by 64 feet 8 inches, with a basement; a boiler-room, 79 feet 10 inches by 56 feet 2 inches; and a coal-room 65 feet 4 inches by 62 feet, connected with the boiler-room by an extension 43 feet 8 inches by 19 feet 10 inches.

West of the pumping-station is a circular screen-chamber, which is connected with the Cochituate aqueduct by a brick conduit 4 feet by 4 feet 4 inches in section, and with the 48-inch pipe from the Sudbury conduit by a 36-inch iron pipe. A third connection can be made with Chestnut-Hill reservoir by a 48-inch pipe when desired, the pipe for this connection being laid from the screen-chamber to the centre of Beacon street. Through these connections water can be drawn directly from either the Cochituate or the Sudbury conduit, or from the reservoir, as may from time to time seem best.

Double screens made of copper wire can be placed in grooves built into the masonry, and iron sluice-gates and stop-planks are arranged for controlling the flow of the water.

A brick conduit 4 feet by 5 feet in section connects the screen-chamber with the pump-wells in the basement of the engine-room. There are three wells; two of them are each 18 feet by 10 feet and 16 feet deep, and the third, which was provided for a future pumping-engine, is 21 feet by 10 feet by 16 feet.

These wells are connected with the conduit through 3 feet by 3 feet iron sluice-gates.

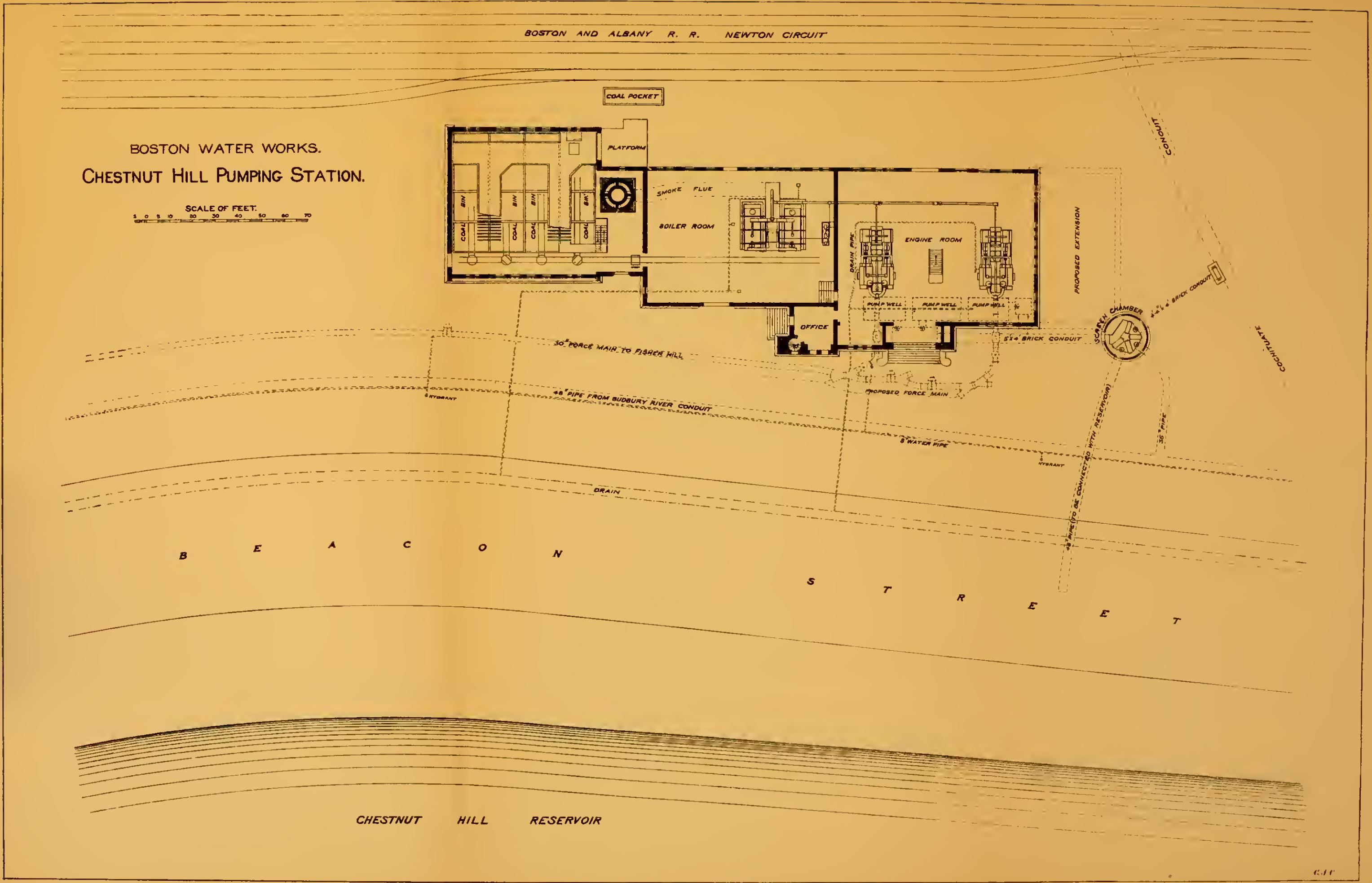
In order to provide for the possible extension of the engine-room for a fourth pumping-engine, a gate-opening for a proposed pump well has been built into the foundation wall on the west end of the building, and the bottom of a foundation wall between the present building and the screen-chamber has been built, so that an extension to the present building can be built at any time without interfering with the operation of the present pumping-plant.

Each well can be emptied through a 12-inch drain-pipe, which also receives the waste water from the condensers of the engines.

The basement has a concrete floor, and in it will be fitted up a repair shop.

The pumping plant consists of two Gaskill horizontal compound engines, each having a capacity of 8,000,000 gallons in 24 hours; they were built by the Holly Company, of Lockport, N.Y.

The high-pressure cylinders are 21 inches diameter, the low-pressure cylinders 42 inches diameter, the water-plungers 25 inches diameter, and all have a stroke of 36 inches. The plunger displacement is 302 gallons per revolution, and the maximum piston speed, as per contract, is 115 feet per minute. The foundation of each pump consists of a solid block of American cement concrete 14 feet 5 inches in thickness, and on each foundation are built four brick piers 6 feet 8 inches high, surmounted by a granite coping 12 inches in thickness. The engines and pumps are secured in position by 1¾-inch bolts, which are built into the entire depth of the brick foundations. The force mains from each pump are 24 inches in diameter, and they unite outside of the building with a 30-inch pipe, which extends to Fisher-Hill reservoir, — a distance of 5,800 feet. Branches and gates have been placed in the force main, so that a third and fourth pumping-engine can be



BOSTON WATER WORKS.

CHESTNUT HILL PUMPING STATION.

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connected with the force main without stopping the pumping. Branches have also been located for a second force main.

The steam is furnished by two horizontal tubular steel boilers, 78 inches in diameter, 18 feet 5 inches long. The shell is $\frac{7}{16}$ inch thick, and each boiler contains 151 tubes, 3 inches in diameter. Each boiler contains 2,171 square feet of heating surface and 49 square feet of grate surface. A feed-water heater is placed in the flue between the boilers. It is made of 80 brass tubes, each 2½ inches diameter and 15 feet long, supported by racks on a portable carriage. It has a heating surface of 931 square feet. The main steam-pipe from the boilers to the engine-room is 10 inches in diameter. The smoke-flue from the boilers to the chimney is of brick, and is carried under the floor of the boiler-room.

The chimney is located in the extension of the coal-house. It is 150 feet in height above the floor of the boiler-room, and the foundations extend to solid earth at a depth of 26 feet. The foundation is 27 feet 10 inches square at the bottom, and is stepped in to 20 feet square at the grade of the bottom of the flue where the brick masonry begins.

The foundation is of Portland cement concrete to a height of 6 feet above its base, and the upper portion is of rubble masonry laid solid in American cement mortar. A door is placed in the chimney at its base for the removal of soot, and an opening for a second smoke-flue has been built and bricked up until needed. The chimney is drawn into a circular form above the opening for the flues. The outside shell at the base is 15 feet in diameter and is 28 inches thick; it has an outside batter of 0.288 inches per foot, and its thickness is gradually reduced to 16 inches at a point 96 feet above the floor. The flue is circular, its inside diameter is 5 feet 6 inches, and its wall is 12 inches thick at the base and 4 inches at the top, which is 20 feet below the top of the outside shell. The chimney has a cast-iron cap, and is fitted with two ½-inch copper lightning-rods.

The coal-room contains four bins, 51 feet long, 14 feet 6 inches wide, and 13 feet high; they will hold about 1,000 tons of coal.

The coal is raised to an elevated run, from which it is dumped into the bins. Scales are provided so that the coal can be weighed before dumping.

EAST BOSTON AND BREED'S ISLAND HIGH SERVICE.

The works will soon be in working order. The pumping-station is built of brick, with brown-stone trimmings, and is located on Condor street, nearly opposite Brooks street.

The supply is taken through a 16-inch suction-pipe, which connects with the 24-inch pipe which crosses Chelsea creek near this point.

A 12-inch force main is laid from the pumping-station to the reservoir on Brooks street; and another 12-inch force main is laid from the pumping-station, a distance of 11,000 feet, to a wrought-iron tank on the summit of Breed's Island, or Orient Heights. This tank is 24 feet in diameter and 40 feet high. The bottom of the tank is 154.60 feet above water-works base.

The two pumps now located in the old pumping-station at the reservoir lot will be moved into the new building to furnish the supply for the East Boston high service, and one of the pumps from the discontinued Brighton pumping-station will be used for the Breed's Island service.

The piping is so arranged that all the pumps can be used for either district.

Contracts for this work have been made as follows: —

Pumping-station, Donahue Bros. & Co. . .	$8,650 00
Pump foundations, J. H. Etridge, Nov. 10, 1888,	316 25
Boilers, — two, — E. Hodge & Co., Nov. 30, 1888	838 00
Tank, George Miles, March 13, 1888 . .	2,420 00

The foundations of the tank and the laying of the water-pipe were done by the day.

MYSTIC LAKE.

Water was wasted over the dam from January 1 to January 22, from February 5 to February 9, from February 20 to June 3, from June 14 to June 16, and from September 26 to December 31.

The lowest point reached during the year was on September 17, when the surface of the lake was at grade 4.26, or 2.74 feet below high water.

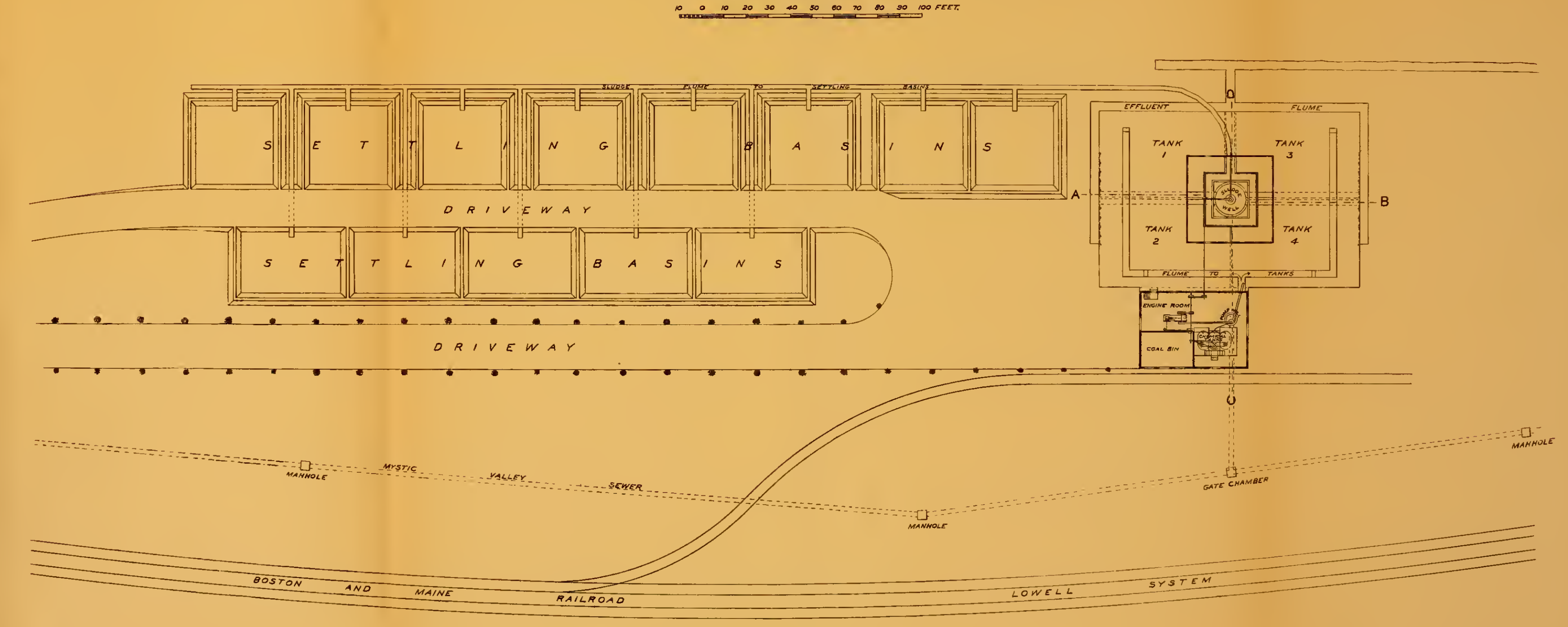
MYSTIC–VALLEY SEWER.

The new settling-tanks have been completed and are in successful operation. The works consist of a pump well connected by a brick sewer with the main sewer, a sewage-pump, an engine, an engine-house, four settling-tanks, a sludge-well, a sludge-pump, and a series of settling-basins for receiving the sludge.

BOSTON WATER WORKS.

General Plan of Mystic Valley Sewerage Works.

SCALE.



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In the engine-house are three vats, so arranged that the precipitant is fed to the sewage from one vat placed lower and between the other two, in which the precipitant is dissolved; each vat is provided with a steam-pipe for heating the water used, and with an appliance for stirring, which is run from the engine.

After the precipitant is fed to the sewage, it is raised by pumping to the settling-tanks, where, after a tank is filled, it is allowed to settle for about three hours. The clarified liquid is then drawn off by means of narrow stop-planks, which are removed one by one. At this season of the year the tanks can be filled six times before it is necessary to remove the deposited sludge. This is removed through sluices which connect with a sludge-well placed in the middle space between the four tanks. From this sludge-well the sludge is pumped into a flame, by which it is carried to the settling-basins.

The average flow of the sewer is about 400,000 gallons in 24 hours, 75 per cent. of which is between 8 A.M. and 8 P.M. After 12 P.M. the flow from the sewer is practically clear water.

The results of several experiments show that 1 volume of sludge is deposited in the tanks to 30 volumes of sewage received. The sludge contains about 4 parts of dry solids to 96 parts of water; the water disappears in the settling-basins, and we have remaining a product sufficiently dry to be easily handled, and containing 4 parts of solids to 12 parts of water. On this basis the amount of "dry product" would be 10 cubic yards daily. The cost of the works, including the preparation of the settling-basins and incidentals, was $10,410.18.

The accompanying plan and section shows the arrangement of the works.

MYSTIC CONDUIT AND RESERVOIR.

The conduit has been cleaned twice during the year, and is in good condition.

The eastern division of the reservoir was cleaned in 1884, and the other division should be cleaned out this year. The stone masonry of the western division has been repointed.

MYSTIC PUMPING-STATION.

The repairs to the roof of the pumping-station were completed early in the year. The flat roof of the coal bunker, which was badly decayed, has been replaced by a shed roof.

The four old boilers have about outlived their usefulness, and it would be economy to replace them with a new plant.

Engine No. 1 was in use	1,703 hours	55 minutes	pumping	279,878,500 gallons.
" " 2 " "	2,689 "	30 "	"	494,328,700 "
" " 3 " "	7,482 "	45 "	"	2,248,115,200 "
Total amount pumped				3,022,322,400 "

Total amount of coal consumed, 6,924,000 lbs.
Percentage ashes and clinkers, 8.4.
Average lift, in feet, 147.65.
Quantity pumped per pound of coal, 436.5 gallons.
Average duty of engines, no deductions, 53,750,600 ft. lbs. per 100 lbs. of coal.
Daily average amount pumped, 8,257,700 gallons, an increase of 8.2 per cent.

Cost of Pumping.

Salaries	$8,731 65
Fuel	13,684 02
Repairs	1,075 76
Oil, waste, and packing	790 59
Small supplies	102 73
Total	$24,384 75

Cost per million gallons raised one foot high, 5.48 cents.

DISTRIBUTION.

During the year the following changes have been made in the distribution system: —

Size of Pipe.	SUDBURY-COCHITUATE WORKS.		MYSTIC WORKS.	
	Total Length laid and relaid.	Length of Pipe abandoned.	Length laid.	Length abandoned.
4	799	7,570	1,263	6,225
6	59,449	4,811	6,276	. .
8	15,008	215	. .	. .
10	2,744	. .	126	. .
12	29,328	3,002	487	. .
16	6,129	262	1,286	. .
20	58	170	. .	. .
24	3,400	. .	115	. .
30	5,709	. .	427	. .
Total length	122,624	16,030	9,980	6,225

The total length of pipe laid on the Sudbury and Cochituate works was 23.22 miles, and 3.04 miles have been abandoned, making a net increase of 20.18 miles in the total length in use. On the Mystic works the mains have been extended 9,980 feet, and 6,225 feet of 4-inch wrought-iron and cement pipe have been abandoned

The 24-inch main to East Boston, the laying of which was commenced in 1887, has been completed between City square in Charlestown and Chelsea creek in Chelsea, and the new 30 and 16 inch mains have been laid with the exception of the portion on Warren bridge. The new 30-inch main has been connected with the old 20-inch pipe at each end of the bridge, and the pressure on the pipe in East Boston is increased 10 or 12 pounds. The 30-inch main starts from the 40-inch main on Boston Common opposite Mason street, and runs diagonally across the Common to the corner of Park and Beacon streets, thence through Beacon, Bowdoin, Allston, and Bulfinch streets, Bowdoin square, Chardon, Portland, Traverse, Haverhill, Causeway, and Beverly streets to Warren bridge, where it connects with the old 20-inch main. A connection has also been made with the old 24-inch main in Chardon street. These two connections with the new main have increased the head in the pipes at the north end of the city.

The 16-inch high-service main was laid from the corner of Mt. Vernon and Joy streets, through Joy, Myrtle, Derne, Bowdoin, and Cambridge streets to Chardon street, and from this point to Warren bridge the 16-inch and 30-inch pipes are laid in the same trench. On the Charlestown side the 30-inch and 16-inch pipes start near the crossing of the freight railroad on Warren avenue, and are laid in the same trench to City square, where the 30-inch is reduced to 24-inch, and connections are made with the 20-inch Cochituate and the 16-inch Mystic mains. The 24-inch and 16-inch pipes continue through Park street to Common street, where the pipes separate, the 16-inch running to Monument square, through Common and Winthrop streets, and the 24-inch through Common, Adams, and Chelsea streets to Chelsea bridge. The new 24-inch pipe was laid through the filled portion of Chelsea bridge, but the new 24-inch and the old 24-inch pipes are connected and carried over the bridge proper in one line of 30-inch pipe. In Chelsea the new 20-inch pipe was laid in Broadway, Williams, and Marginal streets, and is connected with the old 20-inch and 24-inch pipes crossing Chelsea creek to East Boston. When the 30-inch is laid across Warren bridge there will be two independent lines to East Boston, with the exception of the sections on Chelsea bridge.

A contract was made with the Gloucester Iron Works on

July 17, for furnishing 440 tons of 6-inch water-pipe for the supply of Long Island, and on August 3 a contract was made with Geo. W. Townsend for furnishing and laying a line of 6-inch pipe, with John F. Ward's flexible joints, between Moon and Long Islands. Each length of pipe between Moon and Long Islands was encased by four spruce planks, 11 feet 4 inches long and 3½ inches thick, and the space between the case and the pipe was filled with lime and cement grout, to protect the iron from the sewage that is discharged near that point. The pipe is placed below the surface of the bottom of the channel wherever there is less than 10 feet of water at mean low tide. The length of the line is 3,415 feet. The pipe was laid for a distance of 10,270 feet on Moon Island, and through Squantum. All further progress was delayed by complications with the town of Quincy. A contract was made with J. N. Hayes & Co. for building the siphon and pipe-box at Neponset bridge, for $8,000; but the work was delayed for the same reason.

MISCELLANEOUS.

The pipe yard on Albany street has been enlarged by taking the adjoining wharf, formerly occupied by the City Hospital Department, and a sea wall, 168 feet in length, was built on the water front to replace the old wall, at a cost of $5,965.90.

The following is a report from Mr. Desmond Fitz Gerald, Resident Engineer, of the work intrusted to his charge: —

BOSTON, Jan. 1, 1889.

WILLIAM JACKSON, ESQ., *Chief Engineer, Boston Water-Works:* —

SIR, — I submit herewith a brief report of the engineering work accomplished during the past year by the force on additional supply and improvement of the old sources.

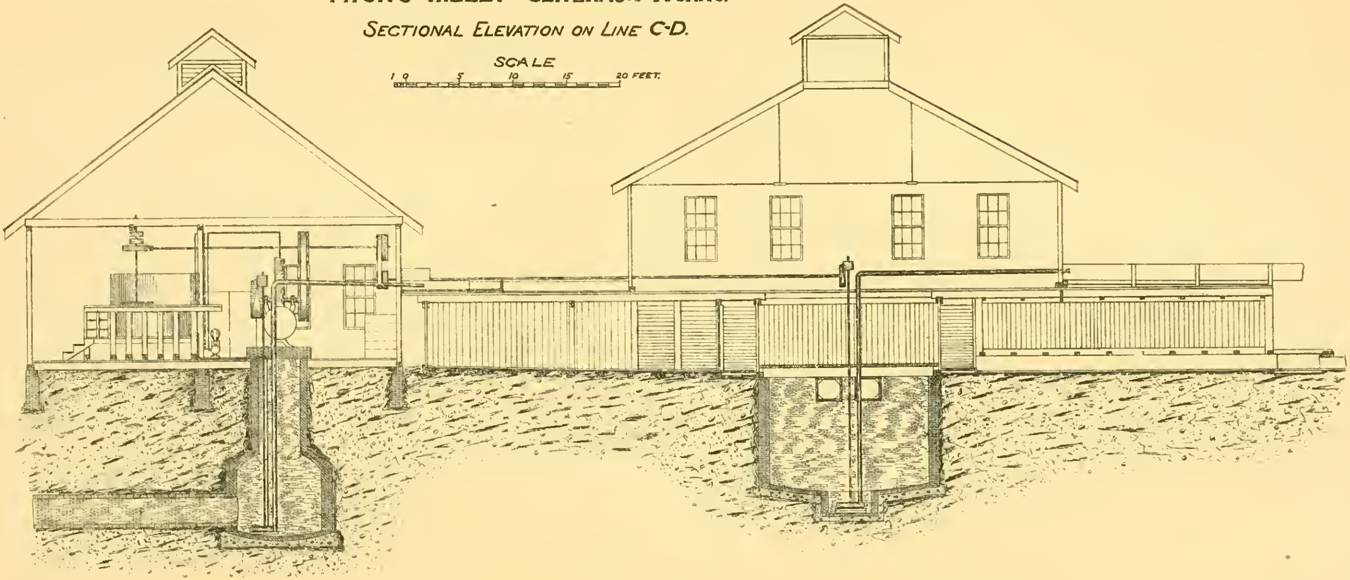
Early in the year borings were begun at Basin 5 to ascertain the depth of the bed-rock below the surface of the valley, at the site of the dam. Two test-pits were partially sunk, but their indications were so different from the water-borings that it became evident that little reliance could be placed on the ordinary wash-out system. The ground is so full of large boulders that it will be necessary to use the diamond drill. On March 10 all work on the new basin was suspended, from lack of appropriations.

During the summer, surveys were made of the Course brook and Pegan meadows, at Lake Cochituate, and plans perfected for their improvement, by lowering the grade of the

BOSTON WATER WORKS.

MYSTIC VALLEY SEWERAGE WORKS.

SECTIONAL ELEVATION ON LINE C-D.



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bottom, and filling the shallow portions. On August 20 a contract was made by the Water Board with Auguste Saucier for the removal of 60,000 cubic yards of material at the Pegan meadows, and this work has just been satisfactorily completed.

Plans for new location of the highways on the site of Basin 5 have been made during the year, and have been accepted by the County Commissioners of Middlesex County.

Some experimental work on the subject of filtration has been prosecuted by the force under my direction, but the results are not sufficiently advanced to report upon at the present time.

Very truly yours,

DESMOND FITZ GERALD,
Resident Engineer.

HIGH SERVICE.

The high-service district in the city proper is now supplied by a 24-inch pipe from Parker-Hill reservoir to Pynchon street, a distance of 2,900 feet; thence by a 20-inch pipe to Berkeley street, a distance of 4,520 feet, where the 12-inch pipe for the South Boston supply is taken off; thence by a 16-inch pipe to the 16-inch by 16-inch branch on Boston Common, a distance of 2,600 feet. During this season a large territory has been added to the high-service district in the city proper, and it is also proposed to make connection so that a portion of the Charlestown district can be supplied when the Mystic supply runs short. Estimating the maximum flow at present to be 1½ times the average consumption, there is a loss of head at the 16-inch by 16-inch branch of 25 feet, besides a sudden momentary additional loss of head of 30 feet, caused by the large draught of elevators. To remedy this excessive loss of head, it is necessary to provide an additional line of pipe from Parker-Hill reservoir. The additional line of pipe is also desirable in the contingency of an accident to the present line. I therefore recommend that a 20-inch main be laid from the present 24-inch pipe in Fisher avenue, at Parker Hill, to the 16-inch by 16 inch branch on the Common.

In the Roxbury and Dorchester high-service districts the present consumption is about 2,500,000 gallons daily, and in the higher portions of the districts the supply is at times unsatisfactory. To remedy the trouble now existing and to provide for the future wants of this growing district, it is necessary to lay a new main from the 16-inch pipe at the corner of Parker and Centre streets, to the vicinity of Eggleston square, where, by being extended as necessity may require, it can be connected with the 12-inch pipes in Washington street and Walnut, Humboldt, Elm Hill, and Blue Hill avenues; also the 12-inch pipe in Seaver street should be connected from Walnut avenue to Maple street; and the connection between the 16-inch pipe in Centre street and the 24-inch pipe in Perkins street should be changed to 16-inch.

The sizes of pipes recommended above are based on the assumption that, when required, a main will be laid for the supply of Dorchester by way of Forest Hills and the proposed reservoir in West Roxbury.

ADDITIONAL SUPPLY.

The capacity of the combined Sudbury and Cochituate supplies, as at present developed, is 35,500,000 gallons daily for a dry year. The consumption for the past year was 33,310,700 gallons daily, an increase of 11.6 per cent. over the consumption of the previous year. Assuming that the increase for the next year will be equal to that of last year, the consumption will reach 37,174,700 gallons daily. That is, our consumption would be more than the dry years' capacity of our supply as at present developed. It is, therefore, evident that, for the protection of the city against a probable season of short supply of water, it is necessary to begin the further development of its resources at once.

After authority is obtained to proceed with the work of building an additional basin, several months will be required or necessary investigations and studies before the actual construction of a storage-basin can be proceeded with. The work of construction can, under the most favorable conditions, be completed in three working seasons; nearly one season will be required for the preliminary work, and the basin should be allowed to be filled one year before water is used from it; thus five years are required for the completion, ready for use, of a storage basin.

The figures below give the daily average rates of consumption for the past five years from the Sudbury and Cochituate works: —

1884 . . .	25,090,500 gallons.
1885 . . .	25,607,200 "
1886 . . .	26,627,900 "
1887 . . .	29,852,100 "
1888 . . .	33,310,700 "

The above shows an increase for the four years past of 32.8 per cent. Assuming the same rate of increased consumption, we should have in 1892 a daily average consumption of about 44,250,000 gallons. It is not believed, however, that the increase during this period will be at this rate; but a comparison of the rates of increase in the past five corresponding periods shows that it is reasonable to expect that the increase may not be less than 10 per cent. This percentage is based upon the assumption that it is safe to allow for a considerable reduction in the amount of water wasted, the waste of last year being largely increased by the long-continued cold weather during the early months. We may anticipate with reasonable certainty that in 1892 our water-works will be called upon to supply at least 36,750,000 gallons daily to the district now supplied by the Cochituate and Sudbury works; and should any additional territory now supplied from other sources be supplied from these works, this amount would be proportionately increased.

The capacity of the additional basin, for which the land has been partly acquired, is 4,500,000 gallons daily, and it will be seen, from the above, that even with the development of this basin, the works, with no allowance for possible additions to the territory now supplied, will have but a comparatively small surplus capacity.

C. — MAIN DRAINAGE WORKS.

The following is a statement of the condition of the appropriation for Improved Sewerage Construction, Jan. 1, 1889: —

Total appropriations	$5,412,994 93
Expended to Jan. 1, 1889	5,400,795 29
Balance	$12,199 64

The available balance is about $6,000 less than the above, on account of amounts due under existing contracts.

The construction work for the past year was principally in Huntington avenue, where the location of the main sewer is crossed by the new channel for Stony Brook, at an expense of $3,162.81; $1,521.42 was paid on account of a judgment of the court in favor of Lucy Ellis, section 4, East side; $1,660.15 was paid for the third edition of the "History of

Main Drainage;" $768.50 was paid for a "sludge carrier," and the balance of the expenditure was on account of the work of the previous year.

The necessity for further extension of the main-sewer system is becoming more and more apparent, and the outlook is encouraging for the adoption in the near future of plans for the completion of the work now so successfully commenced by the present main-drainage system of Boston.

SURVEY OF SEWERS.

An order was passed by the City Council, "That the Mayor be, and hereby is, requested to direct the Superintendent of Sewers, the City Engineer, and the City Surveyor to make a survey of all existing sewers, and to consider and report to the City Government the necessity of new sewers, and a systematic plan for their construction in the future;" and in compliance with the following order of the Mayor, dated Feb. 18, 1888, "In accordance with an order passed by the City Council and approved this date, you are hereby directed, in conjunction with the Superintendent of Sewers and City Surveyor, to make a survey of all existing sewers, and to consider and report to the City Government the necessity of new sewers, and a systematic plan for their construction in the future," a meeting of these officers was held at the office of the City Engineer, February 20, and it was voted to request the City Council for an appropriation of $40,000, and the following communication was sent to His Honor the Mayor: —

Office of City Engineer,
Boston, Feb. 20, 1888.

Hon. Hugh O'Brien, *Mayor*.

Dear Sir, — In compliance with your communication of February 18, directing the Superintendent of Sewers, the City Engineer, and the City Surveyor "to make a survey of all existing sewers, and to consider and report to the City Government the necessity of new sewers, and a systematic plan of their construction in the future," we have this day organized and voted to request of the City Council an appropriation of $40,000, for the purposes of making surveys and investigations for that object.

The necessity of doing this work is urgent, and it will be the means of saving a large expenditure to the city in the future.

Respectfully submitted,

(Signed) SETH PERKINS, *Supt. of Sewers.*
WILLIAM JACKSON, *City Engineer.*
THOS. W. DAVIS, *City Surveyor.*

D. — PARKS.

For the purpose of making this report a complete record of the work of this department the following statement, which was made to the Park Commissioners, and printed in their report to the City Council, is given: —

THE PARKWAY. — BACK BAY FENS.

Excavation of Waterway. — In the spring, when the ice left the basin, the work of removing the earth dams across the channel at Agassiz Bridge and filling in the old channel across the Agassiz Road was begun. This was completed early in July.

During the remainder of the season, the dredger has been employed in completing portions of the channel which had previously been partially excavated, the completion of the new channel under Agassiz Bridge making it possible to empty the southerly part of the basin, thus discovering a number of places which were not down to grade, and also showing a considerable deposit from the overflow of Stony Brook. The dredging has been carried on at a considerable disadvantage, as a large part of the material had to be unloaded from the scows by wheelbarrows, all the places where it could be dumped directly from the scows having already been filled.

Grading of Marsh. — This work has been nearly completed, there being now about 19 acres of finished surface between grades 8 and 9, less than one acre remaining to be done.

Drainage. — Drains have been built in Charlesgate East, Charlesgate West, and Agassiz Road. The drains in Charlesgate East discharge into the common sewer, and other drains discharge as described in the report for 1887.

Roadways, Walks, and Rides. — April 9 a contract was made with the B. & A. R.R. Co. for delivering gravel. Most of this was used for completing the grading of Agassiz Road, and of Audabon Road from Agassiz Road to its junction with the Fenway, the balance being deposited on the southerly part of the Fenway. This work was completed August 9, and there were delivered 47,745 cubic yards of gravel, at $0.57 per cubic yard.

On February 28 a contract was made with Albert A. and James O. Libby for furnishing curbstone for that portion of the Parkway between Beacon street and the Boston & Albany

Railroad. There were delivered $3,407\frac{7}{12}$ linear feet of curbstone, at $1.59 per linear foot.

A contract was made with John Shields for furnishing paving-blocks, under which he delivered 60,518 blocks, at $44.37 per M.

The roadways and walks on the Parkway north of and including the Agassiz Road left incompleted last season have been graded and macadamized in the same manner as was described in the last annual report, the curbstones have been set and the gutters paved, so that this portion of the Parkway is entirely completed, excepting the planting of trees upon the borders of a portion of the drives, and the providing of some system of lighting.

In addition to the above, about 1,700 linear feet of Audubon Road southerly from Agassiz Road, has been sub-graded in readiness for setting the curbstone and macadamizing the roadway.

Agassiz Bridge. — This bridge, which was fully described in the last annual report, was completed in February with the exception of the parapet wall, which it is thought best to leave until the back-filling has settled.

Grading of Slopes, Loaming, and Planting. — This work has been continued during the season, and there is a large area ready to be planted in the spring. The slopes between Agassiz and Audubon Roads and the basin, the large island in the southerly portion of the basin, and the mounds on the marsh near by, are ready for planting, and a large amount of grading has also been done on the slope between the Fenway and the basin.

On June 13 a contract was made with the Metropolitan Construction Company, under which they have deposited on the slopes of the Fenway 8,538 cubic yards of earth, at $0.40 per cubic yard.

The Sewer Department has also deposited a large amount of earth excavated from the new channel of Stony Brook on the Fenway and adjoining slopes.

The following table, giving some of the items of work completed on the Parkway at Back Bay to date, may be of interest. A great deal of unfinished work which has been done on other portions of the Parkway, much of which is very near completion, is not contained in the table: —

		Percentage of whole amount to be done.
Channel excavated . . .	1,148,000 sq. ft.	82
Shore completed . . .	23,000 lin. ft.	90
Marsh " . . .	817,000 sq. ft.	95
Driveway completed . .	41,000 sq. yds.	47
Walks " . . .	16,000 sq. yds.	30
Ride " . . .	3,000 sq. yds.	23
Curbing completed . . .	18,900 lin. ft.	50
Gutters " . . .	9,200 sq. yds.	45
Area covered with loam completed	701,000 sq. ft.	51
Area planted with loam completed	512,000 sq. ft.	37

In addition to the above, there have been built 4,663 linear feet of drains, 6 man-holes, and 55 catch-basins.

ARNOLD ARBORETUM.

The work of construction done during the past year has been confined to the planting of the slopes of the driveway to the top of Bussey Hill, where they are included within the city's reservation.

Some slight repairs have also been made on the drives and walks.

FRANKLIN PARK.

Drives and Walks. — The Glen, Pierpont, and Playstead Roads, together with a section of the Greeting to connect the two latter, and the entrances from Walnut avenue, have been completed.

The walks adjoining these roads have also been completed with the exception of a short length in the rear of the Shelter building. Glen Lane, for a length of about 2,400, and the circuit-drive in the Country Park, for a length of about 3,000 feet, have been graded.

On March 24 a contract was made with S. & R. J. Lombard for furnishing paving-blocks, and 111,106 blocks were delivered, at $48 per M.

The Overlook. — The wall has been entirely completed and the face of it planted. Seats have been constructed of stone and covered with oak slats. The walk and the steps leading from the driveway have been finished, and four rustic drinking-fountains have been built of the stone found upon the park.

The Shelter. — This building is nearly completed, the excavation, the foundations, the masonry side-walls, the chimneys above the roof, and the outside steps having been constructed by the park force, while the carpenter-work has been done by contract, under the direction of the City Architect. All the exposed masonry is of field stone, laid so as to show weather-worn and mossy-faces. The remainder of the building is covered with rived cypress shingles.

Playstead Green. — The grass-seed sown in the fall of 1887 has produced a fine turf, the care of which has required considerable labor, the grass having been kept cut short by means of lawn-mowers.

A flag-staff, consisting of a single stick 105 feet in length, has been erected. It stands upon a ledge, in about the centre of the green, and rests upon a cast-iron foot bolted to the ledge, the staff being supported laterally by three wire-rope guys attached to anchor-bolts set in the rock.

Gateways. — At the entrance to the Country Park, from the Playstead district, it is designed to have gates for closing this part of the park at night. Plans for these gateways were prepared by Messrs. Walker & Best, architects. There will be four wrought-iron gates, two for the driveway and one for each of the footpath entrances, which will run upon tracks laid across the driveway and walks. When the Country Park is open, these gates will be run into chambers of rustic masonry, which have been built for that purpose. Adjoining the gateway, about 230 feet of retaining-wall have been built on the line of Glen Lane.

Ellicott Arch. — The circuit drive will cross a footpath leading from the entrance at the junction of William street with Forest Hill street upon an arch of masonry. Work upon this arch was begun in midsummer, but was discontinued when the force was needed on other work.

The work has recently been resumed, and the arch will be completed early next season.

The following tables give some of the items of the work which has been completed to date. As is the case in the statement given in reference to the Parkway, a large amount of work has been done which cannot be stated in figures; such as clearing of grounds of trees and rocks, grading of grounds which have not as yet been finished, etc. : —

Driveways	27,225	sq. yds.
Walks	20,000	"
Gutters paved	4,923	"
6-in. water-pipe laid	3,000	lin. ft.
Hydrants	3	
Drinking-fountains	4	

2-ft. brick drain	519	lin. ft.
18-in. pipe "	1,233	"
15-in. " "	983	"
12-in. " "	805	"
10-in. " "	989	"
8-in. " "	3,087	"
4-in. agricultural tile drain	900	"
3-in. " " "	1,200	"
2-in. " " "	9,500	"
Total drains	19,140	lin. ft.
Man-holes	13	
Catch-basins and inlets	50	

The area of ground graded and planted or seeded, and not included in above table, is 34 acres.

MARINE PARK.

Iron Pier. — The building of the iron pier was suspended, on account of unfavorable weather, from January 15 to February 20, from which latter date the work was continued till November 7, when the work called for under the contract of July 11, 1887, was completed.

The connection between the temporary wooden pier and the iron pier was completed October 13, and the iron railings and lamp-posts were finished and in place December 8.

The completed portion of the iron pier was opened to the public on December 2.

The total length of the seventeen spans of pier now completed is 1,049.75 feet, and the four additional spans contracted for October 20 will increase the length to 1,296.75 feet.

Curbstone. — On April 18 a contract was made with the Lanesville Granite Company for furnishing an ornamental curb to be set on the line between the park and Q street. This contract was completed October 17, and there were furnished 1,390⅓ lin. ft. of curbstone at $2.75 per foot. The stones have been set, and a small amount of grading done back of them.

In August a new and larger service-pipe was laid to connect the refectory building with the main water-pipe, the old pipe not having sufficient capacity to supply the increased demand for water due to the putting in of additional fixtures.

Wood Island Park.

The only work done upon this park during the year has been the construction of the iron bridge over the Boston, Revere Beach, & Lynn Railroad. This was completed, with the exception of the railing, on September 25, and the railing was completed in November. The approaches to the bridge have been graded.

Charles River Embankment.

In February the old buildings adjoining the West Boston Bridge were removed, and in April the Paving Department completed the removal of their buildings. The work of grading the park grounds has been completed, the areas for planting have been covered with loam and fertilized, and the drainage has been completed. An iron railing has been erected on the Embankment wall, with lamp-posts about 50 feet apart, and gas-pipes connecting with the mains of the Boston Gas Light Company have been laid to these lamp-posts. An iron fence has been erected around the gymnastic grounds at the northerly end of the Embankment, and these grounds have been prepared for their intended use with the exception of the erection of some apparatus.

The filling of the embankment has been extended under the West Boston Bridge by a sloping bank protected by rip-rap. This was done to prevent the thrust of the filling from moving the bridge. The gravel used was dredged from Charles river. The work was done by John T. Scully, at a cost of $2,598.77, and was completed in October.

Gravel walks have been made wherever called for by the plans. It is not thought best to construct expensive walks at present, as the ground has been but recently filled, and is liable to considerable settlement.

The following table gives a statement of the work completed: —

Area of ground covered with loam in readiness for planting	262,000 sq. ft.
Area of walks completed	109,000 sq. ft.
Area of gymnastic ground	65,000 sq. ft.
Drains laid	1,220 lin. ft.
Man-holes built	10
Catch-basins	17
Iron railing on sea-wall	2,250 lin. ft.
Lamp-posts " "	52
Iron fence around gymnastic ground . .	1,184 lin. ft.

MUDDY RIVER AND STONY BROOK COVERED CHANNELS.

Examinations have been made of these channels from time to time, and the portions of each where the foundation is in moving mud will have to be rebuilt or strengthened by inside bracing. A portion of the Muddy River conduit is temporarily strengthened, as described in last year's report.

The table showing the widths of draw-openings in the bridges over tide-water in this city is given in the Appendix. The openings have all been remeasured for this report.

WILLIAM JACKSON,
City Engineer.

CITY ENGINEERS.

1850-1888.

E. S. Chesbrough, M. Am. Soc. C. E., Nov. 18, 1850, to Oct. 1, 1855.[1]

James Slade, Oct. 1, 1855, to April 1, 1863.[2]

N. Henry Crafts, April 1, 1863, to Nov. 25, 1872.

Joseph P. Davis, M. Am. Soc. C. E., Nov. 25, 1872, to March 20, 1880.[3]

Henry M. Wightman, M. Am. Soc. C. E., April 5, 1880, to April 3, 1885.[4]

William Jackson, M. Am. Soc. C. E., April 21, 1885, to present time.

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[1] Died August 18, 1886.

[2] Died August 25, 1882.

[3] Resigned March 20, 1880.

[4] Died April 5, 1885.

APPENDICES.

APPENDIX A.

Table showing the Widths of Openings for Vessels in all Bridges provided with Draws, in the City of Boston, January, 1889.

NAME OF BRIDGES.	LOCATION.	NUMBER OF OPENINGS.	WIDTH.	
			Feet.	In.
Boston & Maine R.R.	Boston to Charlestown	1	35	3
" " "	Over Miller's River	1	35	7
Broadway	Over Fort-Point Channel	1	43	3
Cambridge-st.	Ward 25 to Cambridge	1	30	5
Canal	Boston to East Cambridge	1	35	10
Charles-river	Boston to Charlestown	1	36	0
Chelsea (South Channel)	Charlestown to Chelsea	1	38	8
" (North ")	" " "	1	44	6
Chelsea-st. (East Boston side)	East Boston to Chelsea	2	33	4
" (Chelsea side)	" " "		34	3
Commercial-point	Ward 24	1	24	0
Congress-st. (Boston side)	Over Fort-Point Channel	2	43	3
" (South Boston side)	" " "		43	11
Dover-st.	" " "	1	36	0
Eastern R.R.	Boston to Charlestown	1	35	10
" "	Over Miller's River	1	35	7
Essex-st.	Ward 25 to Cambridge	1	30	11

Federal-st.	Over Fort-Point Channel	1	36	0
Fitchburg R.R.	Boston to Charlestown	1	35	9
" " (for teaming freights)	" " "	1	36	0
Grand Junction R.R.	Ward 25 to Cambridge	1	32	2
" " "	East Boston to Chelsea	1	35	0
Granite	Ward 24 to Milton	1	30	11
Lowell R.R. (freight)	Boston to East Cambridge	1	35	8
" " (passenger)	" " " "	1	35	10
Malden	Charlestown to Everett	1	43	4
Meridian-st. (East Boston side)	East Boston to Chelsea	2	59	0
" (Chelsea side)	" " " "		59	0
Mt. Washington-ave. (Boston side)	Over Fort-Point Channel	2	42	1
" " (So. Boston side)	" " "		42	4
Neponset	Ward 24 to Quincy	1	31	1
New York & New England R.R. (Boston side)	Over Fort-Point Channel	2	40	7
" " " (So. Boston side)	" " "		40	10
" " "	Over South Bay	1	28	4
North Beacon-st.	Ward 25 to Watertown	1	30	2
North Harvard-st.	Ward 25 to Cambridge	1	31	8
Old Colony R.R.	Over Fort-Point Channel	1	36	0
" "	Ward 24 to Quincy	1	35	11
Prison-point	Charlestown to Cambridge	1	35	6
Warren	Boston to Charlestown	1	36	3
West Boston (Boston side)	Boston to Cambridge	2	35	8
" (Cambridge side)	" " "		36	0
Western-ave.	Ward 25 to Cambridge	1	31	3
"	Ward 25 to Watertown	1	30	0

APPENDIX B.

CITY ENGINEER'S REPORTS, 1868–1888.[1]

Year.	Doc.	Year.	Doc.	Year.	Doc.
1868	22	1877	15	1883	53
1869–70	14	1878	20	1884	55
1871	15	1879	22	1885	54
1872–73	23	1880	33	1886	41
1874	20	1881	25	1887	38
1875	19	1882	52	1888	39, 117
1876	24				

CONTENTS CITY ENGINEER'S REPORTS,

1868–1888.

SUBJECT.	Year.	Doc.	Page.
Adams-street bridge (over O. C. R.R.)	1885	54	23
“ “ “ “	1886	41	20
“ “ “ “	1887	38	16
Adams-street survey	1868	22	29
Additional water supply	1874	20	15
“ “ “	1875	19	12
“ “ “	1876	24	8
“ “ “	1877	15	37
“ “ “	1878	20	35
“ “ “	1879	22	34
“ “ “	1880	33	27
“ “ “	1881	25	27
Agassiz bridge (in B. B. Fens)	1888	39	33
“ “ “ “	1888	117	5
Albany-street bridge (over B. & A. R.R.)	1868	22	21
“ “ “ “ “	1870	14	37
“ “ “ “ “	1871	15	69
“ “ “ “ “	1873	23	46
“ “ “ “ “	1874	20	35
“ “ “ “ “	1875	19	38
“ “ “ “ “	1876	24	32
“ “ “ “ “	1877	15	24
“ “ “ “ “	1878	20	26
“ “ “ “ “	1879	22	22
“ “ “ “ “	1880	33	17
“ “ “ “ “	1881	25	16
“ “ “ “ “	1882	52	19

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[1] The dates given are for the year in which the document was published.

SUBJECT.	Year.	Doc.	Page.
Albany-street bridge (over B. & A. R.R.)............	1883	53	19
" " " " "	1884	55	19
" " " " "	1885	54	22
" " " " "	1886	41	18
" " " " "	1887	38	14
" " " " "	1888	39	14
" " " " "	1888	117	15
Albany-street bridge (over Roxbury canal)........	1870	14	29
" " " " "	1871	15	54
" " " " "	1873	23	38
" " " " "	1874	20	21
" " " " "	1875	19	19
" " " " "	1876	24	12
" " " " "	1877	15	8
" " " " "	1878	20	8
" " " " "	1879	22	7
Albany-street pipe-yard sea-wall....................	1888	39	24
Albany-street wall..............................	1868	22	12
Alford-street sea-wall............................	1881	25	17
" "	1882	52	20
Algæ..	1880	33	27
Army and navy monument	1875	19	43
Arnold Arboretum, P.............................	1884	55	52
" "	1885	54	51
" "	1887	38	30
" "	1888	39	34
Artesian borings, M. D...........................	1878	20	38
Ashland-street bridge (over B. & P. R.R.)............	1875	19	19
" " " " "	1876	24	13
" " " " "	1877	15	8
" " " " "	1878	20	8
" " " " "	1879	22	7
" " " " "	1880	33	7
" " " " "	1881	25	7
" " " " "	1882	52	8
" " " " "	1883	53	7, 19
" " " " "	1884	55	7
" " " " "	1885	54	8
" " " " "	1886	41	9
" " " " "	1887	38	6
" " " " "	1888	39	5
" " " " "	1888	117	6
Ashmont-street bridge (over O. C. R.R.)............	1884	55	20
Athens-street bridge (over N. Y. & N. E. R.R.).......	1875	19	20
" " " " " "	1876	24	13
" " " " " "	1877	15	8
" " " " " "	1878	20	8
" " " " " "	1879	22	7
" " " " " "	1880	33	7
" " " " " "	1881	25	7
" " " " " "	1882	52	8
" " " " " "	1883	53	8
" " " " " "	1884	55	7
" " " " " "	1885	54	8
" " " " " "	1886	41	9
" " " " " "	1887	38	7
" " " " " "	1888	39	6
" " " " " "	1888	117	5
Atlantic-avenue filling	1871	15	42

SUBJECT.	Year.	Doc.	Page.
Atlantic-avenue retaining wall near Russia wharf	1875	19	41
“ soundings	1870	14	9
“ sea-wall	1871	15	41
“ sidewalk	1883	53	20
“ “	1885	54	24
“ survey	1870	14	9
Back Bay : —			
“ “ Bridges	1873	23	26
“ “ Fens	1888	39	31
“ “ filling	1882	52	43
“ “ “	1883	53	48
“ “ “	1884	55	48
“ “ “	1885	54	49
“ “ “	1886	41	46
“ “ improvement	1886	41	46
“ “ “	1887	38	30
“ “ park	1879	22	24
“ “ “	1885	54	49
Basins, Water-Works : —			
Nos. 2, 3, 4	1884	55	32
Basin No. 4	1885	54	34
Basin 1 dam	1879	22	35
“ 2 “	1880	33	29
“ 3 “	1880	33	30
“ 2 shallow flowage	1884	55	32
“ 3 “ “	1884	55	32
“ 3 “ “	1887	38	18
“ 4 “ “	1886	41	24
Beachmont avenue	1888	39	17
Beacon-entrance bridge : —			
(B. B. Fens, over B. & A. R.R.)	1882	52	45
“ “ “ “	1883	53	8, 48
“ “ “ “	1884	55	7, 50
“ “ “ “	1885	54	8
“ “ “ “	1886	41	9
“ “ “ “	1887	38	7
“ “ “ “	1888	39	6
“ “ “ “	1888	117	6
Beacon-hill high-service W.W.	1871	15	19
Beacon street	1883	53	25
“ “ raising grade	1887	38	16
“ “ “ pipe	1887	38	22
“ “ “ “	1888	39	24
Beacon street and Brookline avenue	1885	54	24
Beacon-street bridge (over B. & A. R.R.)	1873	23	35
“ “ “ “ “	1885	54	3, 8
“ “ “ “ “	1886	41	9
“ “ “ “ “	1887	38	7
“ “ “ “ “	1888	39	7
“ “ “ “ “	1888	117	6
Beacon-street bridge (over outlet of B. B. Fens pond; *see, also,* Mill-dam bridge)	1881	25	18
“ “ “ “ “	1882	52	8
“ “ “ “ “	1883	53	8
“ “ “ “ “	1884	55	8
“ “ “ “ “	1885	54	8
“ “ “ “ “	1886	41	9
“ “ “ “ “	1887	38	7

SUBJECT.	Year.	Doc.	Page.
Beacon-street bridge (over outlet of B. B. Fens pond; *see, also,* Mill-dam bridge)	1888	39	6
" " " " "	1888	117	6
Beacon-street widening	1880	33	21
" "	1881	25	19
Beacon-street and Commonwealth avenue bridges	1882	52	45
Beech-street bridge (over B. & P. R.R.)	1878	20	27
" " " " "	1883	53	19
" " " " "	1884	55	20
" " " " "	1885	54	23
" " " " "	1886	41	20
" " " " "	1887	38	15
" " " " "	1888	39	15
Bellevue-avenue bridge (over B. & P. R.R.)	1887	38	15
" " " " "	1888	39	15
Bennington-street extension	1887	38	16
Berkeley-street bridge (over B. & A. R.R.)	1868	22	23
" " " " "	1870	14	38
" " " " "	1871	15	69
" " " " "	1873	23	47
" " " " "	1874	20	22
" " " " "	1875	19	21
" " " " "	1876	24	14
" " " " "	1877	15	8
" " " " "	1878	20	8
" " " " "	1879	22	8
" " " " "	1880	33	7
" " " " "	1881	25	7
" " " " "	1882	52	10
" " " " "	1883	53	8
" " " " "	1884	55	8
" " " " "	1885	54	8
" " " " "	1886	41	9
" " " " "	1887	38	7
" " " " "	1888	39	7
" " " " "	1888	117	6
Berkeley-street bridge (over B. & P. R.R.)	1870	14	39
" " " " "	1871	15	70
" " " " "	1873	23	47
" " " " "	1874	20	22
" " " " "	1875	19	21
" " " " "	1876	24	14
" " " " "	1877	15	8
" " " " "	1878	20	9
" " " " "	1879	22	8
" " " " "	1880	33	7
" " " " "	1881	25	8
" " " " "	1882	52	10
" " " " "	1883	53	8
" " " " "	1884	55	8
" " " " "	1885	54	9
" " " " "	1886	41	10
" " " " "	1887	38	7
" " " " "	1888	39	7
" " " " "	1888	117	6
Berkeley-street retaining-walls	1871	15	49
" "	1874	20	37
" "	1877	15	26
Berwick-park retaining-wall	1876	24	35

SUBJECT.	Year.	Doc.	Page.
Blakemore-street bridge (over B. & P. R.R.)	1881	25	22
“ “ “ “ “	1882	52	10, 20
“ “ “ “ “	1883	53	9
“ “ “ “ “	1884	55	8
“ “ “ “ “	1885	54	9
“ “ “ “ “	1886	41	10
“ “ “ “ “	1887	38	7
“ “ “ “ “	1888	39	7
“ “ “ “ “	1888	117	6
B. & A. R.R. bridge (over Park water-way)	1882	52	45
“ “ “ “ “ “	1883	53	49
Boilers, Chestnut-hill pumping-station....	1888	39	17
“ Highland “	1878	20	31
“ Mystic “	1884	55	34
Boylston-street arch bridge..........................	1881	25	41
“ “ “	1882	52	44
“ “ “	1883	53	49
“ “ “	1884	55	8, 50
“ “ “	1885	54	9, 50
“ “ “	1886	41	10
“ “ “	1887	38	7
“ “ “	1888	39	7
“ “ “	1888	117	6
Boylston-street bridge (over B. & A. R.R.)	1885	54	50
“ “ “ “ “	1887	38	16
“ “ “ “ “	1888	39	16
“ “ “ “ “	1888	117	7
Boylston-street extension	1876	24	33
Bridges	1868	22	15
“	1870	14	27
“	1871	15	53
“	1873	23	3, 36
“	1874	20	17
“	1875	19	15
“	1876	24	9
“	1877	15	3
“	1878	20	3
“	1879	22	3
“	1880	33	3
“	1881	25	3
“	1882	52	3, 44
“	1883	53	3
“	1884	55	3
“	1885	54	3
“	1886	41	3
“	1887	38	3
“	1888	39	3
“	1888	117	2
Bridges supported by railroad corporations	1874	20	37
“ “ “ “	1875	19	38
“ “ “ “	1876	24	32
“ “ “ “	1877	15	25
“ “ “ “	1878	20	27
“ “ “ “	1879	22	23
“ “ “ “	1880	33	18
“ “ “ “	1881	25	17
“ “ “ “	1882	52	19
“ “ “ “	1883	53	19
“ “ “ “	1884	55	20

SUBJECT.	Year.	Doc.	Page.
Bridges supported by railroad corporations	1885	54	23
“ “ “ “	1886	41	20
“ “ “ “	1887	38	15
“ “ “ “	1888	39	15
“ “ “ “	1888	117	16
Bridges supported by railroad corporations: —			
Adams-street bridge (over O. C. R.R.)	1885	54	23
“ “ “ “ “	1886	41	20
“ “ “ “ “	1887	38	16
Ashmont-street “ “ “ “	1884	55	20
Beech-street “ (over B. & P. R.R.)....	1878	20	27
“ “ “ “ “	1883	53	19
“ “ “ “ “	1884	55	20
“ “ “ “ “	1885	54	23
“ “ “ “ “	1886	41	20
“ “ “ “ “	1887	38	15
“ “ “ “ “	1888	39	15
Bellevue-avenue bridge, “ “ “	1887	38	15
“ “ “ “ “	1888	39	15
Canterbury-street “ “ “ “	1883	53	19
Centre-street “ “ “ “	1881	25	17
“ “ “ “ “	1884	55	20
“ “ “ “ “	1885	54	23
“ “ “ “ “	1886	41	20
“ “ “ “ “	1888	39	15
“ and Mt. Vernon-street bridge (over B. & P. R.R.)	1881	25	17
“ “ “ “	1884	55	20
“ “ “ “	1885	54	23
“ “ “ “	1886	41	20
Commercial-street bridge (over O. C. R.R.) ..	1881	25	17
“ “ “ “ “ ..	1884	55	20
Cottage Farm “ (over B. & A. R.R.)..	1884	55	20
Dudley-avenue “ (over B. & P. R.R.)..	1878	20	27
“ “ “ “ “ ..	1886	41	20
“ “ “ “ “ ..	1887	38	15
“ “ “ “ “ ..	1888	39	15
Fourth-street bridge (over N. Y. & N. E. R.R.)	1880	33	18
Harrison-avenue “ (over B. & A. R.R.)......	1885	54	23
“ “ “ “ “	1886	41	20
“ “ “ “ “	1887	38	15
“ “ “ “ “	1888	39	15
Norfolk-street “ (over N. Y. & N. E. R.R.)	1884	55	20
“ “ “ “ “ “	1885	54	23
Park-street “ (over B. & P. R.R.)	1888	39	15
Second-street “ (over N. Y. & N. E. R.R.)	1877	15	25
“ “ “ “ “ “	1878	20	27
“ “ “ “ “ “	1880	33	18
Sharon-street “ (over B. & P. R.R.).. ...	1878	20	27
Silver-street “ (over N. Y. & N. E. R.R.)	1878	20	27
Sixth-street “ “ “ “ “	1877	15	25
Third-street “ “ “ “ “	1887	15	25
“ “ “ “ “ “	1879	22	23
“ “ “ “ “ “	1880	33	18
Tremont-street “ (over B. & A. R.R.)......	1885	54	23
“ “ “ “ “ “	1886	41	20
“ “ “ “ “ “	1888	39	15
Washington-street bridge (over B. & A. R.R.).	1885	54	23
“ “ “ “ “	1886	41	20

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“ “ “ “ “	1888	39	15
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Brighton temporary high-service works, W.W.	1877	15	33
“ “ “ “ “	1880	33	24
Brighton pumping works, W.W.	1878	20	31
“ “ “ “	1879	22	27
Brimmer-street sewer, M.D.	1884	55	42
Broadway bridge (over Fort-point channel)	1870	14	27
“ “ “ “ “	1873	23	38
“ “ “ “ “	1874	20	22, 50
“ “ “ “ “	1875	19	21
“ “ “ “ “	1876	24	14
“ “ “ “ “	1877	15	8
“ “ “ “ “	1878	20	9
“ “ “ “ “	1879	22	8
“ “ “ “ “	1880	33	8
“ “ “ “ “	1881	25	8, 17
“ “ “ “ “	1882	52	10
“ “ “ “ “	1883	53	9
“ “ “ “ “	1884	55	9
“ “ “ “ “	1885	54	9
“ “ “ “ “	1886	41	10
“ “ “ “ “	1887	38	7
“ “ “ “ “	1888	39	7
“ “ “ “ “	1888	117	7
Broadway bridge (over B. & A. R.R.)	1883	53	10
“ “ “ “ “	1884	55	9
“ “ “ “ “	1885	54	10
“ “ “ “ “	1886	41	10
“ “ “ “ “	1887	38	8
“ “ “ “ “	1888	39	7
“ “ “ “ “	1888	117	7
Broadway extension	1868	22	14, 30
“ “	1870	14	15, 26
“ “	1871	15	42
Broadway extension (over B. & A. R.R.)	1881	25	19
“ “ “ “ “	1882	52	21
“ “ “ “ “	1884	55	20
Brookline avenue	1883	53	25
“ “ raising pipe	1885	54	34
Brookline-avenue bridge (over B. & A. R.R.)	1873	23	35
“ “ “ “ “	1885	54	3, 10
“ “ “ “ “	1886	41	11
“ “ “ “ “	1887	38	8
“ “ “ “ “	1888	39	7
“ “ “ “ “	1888	117	7
Brookline-avenue bridge (over Muddy river)	1874	20	23
“ “ “ “ “	1875	19	24
“ “ “ “ “	1876	24	20
“ “ “ “ “	1877	15	9
“ “ “ “ “	1878	20	10
“ “ “ “ “	1879	22	9
“ “ “ “ “	1880	33	8
“ “ “ “ “	1881	25	8
“ “ “ “ “	1882	52	11

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“ “ “ “ “	1884	55	9
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“ “ City Point	1887	38	17
“ “ Cumberland street	1888	39	17
“ “ Ferdinand “	1884	55	22
“ “ Lowland “	1888	39	26
Bussey park and Arnold Arboretum, P.	1884	55	52
“ “ “ “ “	1885	54	51
“ “ “ “ “	1886	41	47
Cambridge-street bridge (Brighton to Cambridge)	1874	20	32
“ “ “ “ “	1875	19	34
“ “ “ “ “	1876	24	30
“ “ “ “ “	1877	15	21
“ “ “ “ “	1878	20	20
“ “ “ “ “	1879	22	19
“ “ “ “ “	1880	33	12
“ “ “ “ “	1881	25	13
“ “ “ “ “	1882	52	16
“ “ “ “ “	1883	53	15
“ “ “ “ “	1884	55	16
“ “ “ “ “	1885	54	19
“ “ “ “ “	1886	41	16
“ “ “ “ “	1887	38	11
“ “ “ “ “	1888	39	12
“ “ “ “ “	1888	117	12, 18
“ “ proposed	1887	38	18
Cambridge-street crossing (over B. & A. R.R.)	1882	52	25
Camden-street foot-bridge	1885	54	23
“ “	1886	41	20
Canal bridge (Boston to Cambridge)	1873	23	29
“ “ “ “ “	1874	20	35, 48
“ “ “ “ “	1875	19	38, 50
“ “ “ “ “	1876	24	32, 41
“ “ “ “ “	1877	15	25, 43
“ “ “ “ “	1878	20	27
“ “ “ “ “	1879	22	23
“ “ “ “ “	1880	33	17
“ “ “ “ “	1881	25	16
“ “ “ “ “	1882	52	19
“ “ “ “ “	1883	53	19
“ “ “ “ “	1884	55	19
“ “ “ “ “	1885	54	22
“ “ “ “ “	1886	41	19
“ “ “ “ “	1887	38	14
“ “ “ “ “	1888	39	15
“ “ “ “ “	1888	117	15
Canterbury-street bridge (over B. & P. R.R.)	1883	53	19
Castle-street retaining-wall	1873	23	24
Cedar Grove Cemetery bridge (over Shawmut Branch of O. C. R.R.)	1876	24	33
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Cemetery wall, East Boston	1873	23	35
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“ “ “	1878	20	21
“ “ “	1879	22	19
“ “ “	1880	33	13
“ “ “	1881	25	13

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“ “ “	1883	53	16
“ “ “	1884	55	16
“ “ “	1885	54	20
“ “ “	1886	41	16
“ “ “	1887	38	12
“ “ “	1888	39	12
“ “ “	1888	117	13
Centre-street bridge (over B. & P. R.R.)	1884	55	20
“ “ “ “ “	1886	41	20
“ “ “ “ “	1888	39	15
“ and Mt. Vernon-street bridge (over B. & P. R.R.)	1881	25	17
“ “ “ “ “ “	1884	55	20
“ “ “ “ “ “	1885	54	23
“ “ “ “ “ “	1886	41	20
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“ “ “ “	1875	19	24, 48
“ “ “ “	1876	24	21
“ “ “ “	1877	15	9
“ “ “ “	1878	20	10
“ “ “ “	1879	22	10
“ “ “ “	1880	33	8
“ “ “ “	1881	25	9
“ “ “ “	1882	52	11
“ “ “ “	1883	53	10
“ “ “ “	1884	55	10
“ “ “ “	1885	54	10
“ “ “ “	1886	41	11
“ “ “ “	1887	38	8
“ “ “ “	1888	39	8
“ “ “ “	1888	117	7
Charles-river embankment	1884	55	53
“ “	1885	54	52
“ “	1886	41	48
“ “	1887	38	30
“ “	1888	39	36
“ dredging	1876	24	38
Chelsea bridge (Charlestown to Chelsea)	1874	20	32
“ “ “ “	1875	19	34
“ “ “ “	1876	24	30, 46
“ “ “ “	1877	15	22
“ “ “ “	1878	20	21
“ “ “ “	1879	22	20
“ “ “ “	1880	33	13
Chelsea bridge, North (Mystic-river Corporation’s wharf to Chelsea)	1881	25	13
“ “ “ “ “ “ “	1882	52	16
“ “ “ “ “ “ “	1883	53	16
“ “ “ “ “ “ “	1884	55	16
“ “ “ “ “ “ “	1885	54	20
“ “ “ “ “ “ “	1886	41	16
“ “ “ “ “ “ “	1887	38	12
“ “ “ “ “ “ “	1888	39	12
“ “ “ “ “ “ “	1888	117	13

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" " " " " " "	1882	52	11
" " " " " " "	1883	53	11
" " " " " " "	1884	55	10
" " " " " " "	1885	54	11
" " " " " " "	1886	41	11
" " " " " " "	1887	38	8
" " " " " " "	1888	39	8
" " " " " " "	1888	117	8
Chelsea-bridge water-pipe box	1888	39	23
Chelsea-st. bridge (East Boston to Chelsea)	1868	22	20
" " " " "	1870	14	34
" " " " "	1871	15	55
" " " " "	1873	23	41
" " " " "	1874	20	24
" " " " "	1875	19	24
" " " " "	1876	24	21
" " " " "	1877	15	10
" " " " "	1878	20	10
" " " " "	1879	22	10
" " " " "	1880	33	8
" " " " "	1881	25	9
" " " " "	1882	52	12
" " " " "	1883	53	11
" " " " "	1884	55	10
" " " " "	1885	54	11
" " " " "	1886	41	12
" " " " "	1888	39	8
" " " " "	1888	117	8
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Chester-park, East	1882	52	24
Chester-park, West, Extension, bridges	1874	20	37
Chestnut-hill reservoir, Water-Works	1868	22	25
" "	1871	15	5
" pumping-station	1888	39	19
" " boilers	1888	39	17
" " iron roof	1888	39	17
Church-street District	1868	22	31
" " " filling	1870	14	15
Clarke's reports	1880	33	40
" "	1881	25	31
" "	1883	53	33
" "	1884	55	39
" "	1885	54	41
Cleaning water-pipe	1887	38	23
Cochituate Water-Works	1875	19	6
" "	1876	24	4
" "	1877	15	31
" "	1878	20	30
" "	1879	22	26
" "	1880	33	23
" "	1881	25	24
" " and Sudbury river	1876	24	4
" " " " "	1877	15	31
Columbus-ave. bridge (over B. & A. R.R.)	1870	14	40
" " " " "	1871	15	70
" " " " "	1873	23	47
" " " " "	1874	20	26

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" " " " "	1876	24	21
" " " " "	1877	15	10
" " " " "	1878	20	11
" " " " "	1879	22	10
" " " " "	1880	33	9
" " " " "	1881	25	9
" " " " "	1882	52	12
" " " " "	1883	53	11
" " " " "	1884	55	11
" " " " "	1885	54	11
" " " " "	1886	41	12
" " " " "	1887	38	8
" " " " "	1888	39	8
" " " " "	1888	117	8
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" " "	1871	15	59
" " "	1873	23	41
" " "	1874	20	26
" " "	1875	19	25
" " "	1876	24	21, 43
" " "	1877	15	10
" " "	1878	20	13
" " "	1879	22	10
" " "	1880	33	9
" " "	1881	25	9
" " "	1882	52	12
" " "	1883	53	11
" " "	1884	55	11
" " "	1885	54	12
" " "	1886	41	12
" " "	1887	38	8
" " "	1888	39	8
" " "	1888	117	8
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" " " " "	1884	55	20
Commonwealth-avenue bridge (B. B. Fens)	1882	52	45
" " "	1883	53	11, 49
" " "	1884	55	11
" " "	1885	54	12
" " "	1886	41	12
" " "	1887	38	9
" " "	1888	39	8
" " "	1888	117	8
Commonwealth-avenue extension	1881	25	20
" "	1882	52	22
" "	1884	55	21
" "	1885	54	27
" "	1886	41	21
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Conduit, Cochituate W.W.	1874	20	6
" " "	1875	19	7
" " "	1876	24	5
Congress-street bridge (over Fort-point channel)	1875	19	27
" " " " "	1876	24	22
" " " " "	1877	15	11
" " " " "	1878	20	13
" " " " "	1879	22	10
" " " " "	1880	33	9

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" " " " "	1882	52	12
" " " " "	1883	53	12
" " " " "	1884	55	11
" " " " "	1885	54	12
" " " " "	1886	41	12
" " " " "	1887	38	9
" " " " "	1888	39	9
" " " " "	1888	117	9
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" " " "	1888	39	30
Consumption of water	1871	15	39
" "	1874	20	7
" "	1875	19	8
" "	1876	24	5
" "	1877	15	32
" "	1878	20	30
" "	1879	22	27
" "	1880	33	24
" "	1881	25	24
" "	1882	52	28
" "	1883	53	27
" "	1884	55	28
" "	1885	54	31
" "	1886	41	25
" "	1887	38	19
" "	1888	39	18
Copley-square curb	1885	54	28
Cost of pumping, M. D.	1886	41	32
" " "	1887	38	24
" " "	1888	39	25
Cottage Farm bridge (over B. & A. R.R.)	1884	55	20
Covered channel, Stony brook	1881	25	43
" " " "	1882	52	46
" " " "	1883	53	52
" " " "	1884	55	51
" " " "	1885	54	50
Covered channel, Muddy river	1883	53	52
" " "	1884	55	52
" " "	1885	54	50
" " "	1886	41	47
" " "	1888	39	36
Cucumber taste	1882	52	26
Cumberland-street bulkhead	1888	39	17
D-street extension	1881	25	22
" "	1883	53	20
" " bridge	1870	14	44
Dalton-street filling	1885	54	28
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" " " " " "	1871	15	70
" " " " " "	1873	23	48
" " " " " "	1874	20	26
" " " " " "	1875	19	26
" " " " " "	1876	24	26
" " " " " "	1877	15	11, 46
" " " " " "	1878	20	14
" " " " " "	1879	22	11

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" " " " " "	1881	25	10
" " " " " "	1882	52	13
" " " " " "	1883	53	12
" " " " " "	1884	55	12
" " " " " "	1885	54	12
" " " " " "	1886	41	13
" " " " " "	1887	38	9
" " " " " "	1888	39	9
" " " " " "	1888	117	9
Deacon meters	1882	52	32
" "	1883	53	28
" "	1885	54	33
Deer-Island fire-service	1882	52	29
" sea-wall	1871	15	40
" water-pipe	1871	15	21
" wharves	1873	23	31
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" "	1882	52	23, 25
" " for steamboat	1880	33	22
" " " "	1886	41	21
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" " "	1887	38	27
" " "	1888	39	28
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" "	1875	19	10
" "	1876	24	7
" "	1877	15	33
" "	1878	20	32
" "	1879	22	28
" "	1880	33	25
" "	1887	38	22
" "	1888	39	23
Dorchester-avenue grade-crossing	1885	54	29
Dorchester Point, South Boston, P.	1884	55	53
Dorchester-street bridge (over O. C. R.R.)	1870	14	43
" " " " "	1871	15	70
" " " " "	1873	23	48
" " " " "	1874	20	28
" " " " "	1875	19	26
" " " " "	1876	24	26
" " " " "	1877	15	11
" " " " "	1878	20	14
" " " " "	1879	22	23
" " " " "	1880	33	17
" " " " "	1881	25	17
" " " " "	1882	52	19
" " " " "	1883	53	19
" " " " "	1884	55	19
" " " " "	1885	54	23
" " " " "	1886	41	20
" " " " "	1887	38	15
" " " " "	1888	39	15
" " " " "	1888	117	16
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" " " " "	1870	14	29

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" " " " "	1874	20	28, 58
" " " " "	1875	19	26
" " " " "	1876	24	26
" " " " "	1877	15	11
" " " " "	1878	20	14
" " " " "	1879	22	15
" " " " "	1880	33	9
" " " " "	1881	25	10
" " " " "	1882	52	13
" " " " "	1883	53	13
" " " " "	1884	55	12
" " " " "	1885	54	12
" " " " "	1886	41	13
" " " " "	1887	38	9
" " " " "	1888	39	9
" " " " "	1888	117	9
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Dover-street grade-crossing	1885	54	29
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" " " "	1883	53	54
" " " "	1884	55	54, 56
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" " " "	1886	41	52, 54
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" " " " "	1886	41	20
" " " " "	1887	38	15
" " " " "	1888	39	15
Dumping-scow, M. D.	1886	41	23
East Boston cemetery-wall	1873	23	35
" " new main W.W.	1871	15	33
" " " "	1888	39	23
East Boston ferries	1873	23	33
" " "	1883	53	21
" " "	1885	54	28
" " "	1888	39	17
" " " new drop	1871	15	70
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Eastern-avenue extension	1874	20	37
Eastern-avenue steamboat wharf	1876	24	38
" " "	1886	41	21
Ericsson statue	1888	39	17
Embankment wall, P.	1883	53	50
" " "	1884	55	51
Enlargement of water-pipes in East Boston	1871	15	32
Essex-street bridge (Brighton to Cambridge)	1875	19	35
" " " "	1876	24	30
" " " "	1877	15	23
" " " "	1878	20	23

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“ “ “ “	1880	33	13
“ “ “ “	1881	25	15
“ “ “ “	1882	52	17
“ “ “ “	1883	53	16
“ “ “ “	1884	55	16
“ “ “ “	1885	54	20
“ “ “ “	1886	41	17
“ “ “ “	1887	38	12
“ “ “ “	1888	39	12
“ “ “ “	1888	117	13, 18
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“ “ 24-in. “ “ “	1871	15	36
“ “ 30-in. “ Meridian-street bridge	1871	15	35
“ “ 24-in. “ “ “	1871	15	36
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“ “ “	1883	53	50
“ “ “	1884	55	50
“ “ “	1885	54	50
“ “ “	1886	41	46
“ “ “	1888	39	31
Expenses	1868	22	24
“	1870	14	4
“	1871	15	3
“	1874	20	3
“	1875	19	3
“	1876	24	1
“	1877	15	1
“	1878	20	2
“	1879	22	2
“	1880	33	2
“	1881	25	2
“	1882	52	2
“	1883	53	2
“	1884	55	2
“	1885	54	2
“	1886	41	2
“	1887	38	2
“	1888	39	2
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“ “	1870	14	15, 26
“ “	1871	15	42
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“ “ “ “ “	1882	52	21
“ “ “ “ “	1884	55	20
“ Chester park, East	1882	52	24
“ “ “ West (bridges)	1874	20	37
“ D street	1881	25	22
“ “	1883	53	20
“ Eastern avenue	1874	20	37
“ First and Q streets	1873	23	36
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“ “ “	1884	55	24
“ “ “	1885	54	28
“ “ “	1886	41	21

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“ “ “	1875	19	40
“ “ “	1876	24	34
“ “ “	1877	15	27
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“ “ Kilby street	1868	22	29
“ “ W.W., Dorchester	1871	15	26
“ “ “ Roxbury	1871	15	24
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“ “ “ “	1881	25	31
“ “ “ “	1883	53	33
“ “ “ “	1884	55	39
“ “ “ “	1885	54	41
Falmouth-street filling	1883	53	24
“ “	1884	55	21
Farm pond	1874	20	17
“ “ conduit	1884	55	31
“ “ “	1885	54	34
“ “ “	1886	41	26
“ “ “	1887	38	20
“ “ temporary channel	1882	52	27
Federal-street bridge (over Fort-point channel)	1868	22	17
“ “ “ “ “	1870	14	30
“ “ “ “ “	1871	15	54
“ “ “ “ “	1873	23	42
“ “ “ “ “	1874	20	29
“ “ “ “ “	1875	19	28
“ “ “ “ “	1876	24	26
“ “ “ “ “	1877	15	13
“ “ “ “ “	1879	22	15
“ “ “ “ “	1880	33	9
“ “ “ “ “	1881	25	10
“ “ “ “ “	1882	52	13
“ “ “ “ “	1883	53	13
“ “ “ “ “	1884	55	12
“ “ “ “ “	1885	54	13
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“ “ “ “ “	1881	25	10
“ “ “ “ “	1882	52	13
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" " "	1879	22	21
" " "	1880	33	14
" " "	1881	25	15
" " "	1882	52	17
" " "	1883	53	17
" " "	1884	55	17
" " "	1885	54	21
" " "	1886	41	17
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" " " " "	1880	33	11
" " " " "	1881	25	11
" " " " "	1882	52	15
" " " " "	1883	53	14
" " " " "	1884	55	14
" " " " "	1885	54	16
" " " " "	1886	41	15
" " " " "	1887	38	10
" " " " "	1888	39	11
" " " " "	1888	117	11
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" " " " "	1877	15	24
" " " " "	1878	20	25
" " " " "	1879	22	22
" " " " "	1880	33	15
" " " " "	1881	25	15
" " " " "	1882	52	18
" " " " "	1883	53	17
" " " " "	1884	55	17
" " " " "	1885	54	21
" " " " "	1886	41	17
" " " " "	1887	38	12
" " " " "	1888	39	13
" " " " "	1888	117	14
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" " " " "	1879	22	22
" " " " "	1880	33	15
" " " " "	1881	25	15
" " " " "	1882	52	18
" " " " "	1883	53	18
" " " " "	1884	55	18
" " " " "	1885	54	21
" " " " "	1886	41	18
" " " " "	1887	38	13
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“ “ “	1885	54	51
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“ “ “ “	1885	54	49
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“ “ “ “	1884	55	19
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“ “ “ “ “	1887	38	10
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